EXPERIMENTAL STUDIES OF FOUR WILD FRUITS IN THE WINTER DIET OF RING-NECKED PHEASANTS:

I. A METHOD OF DETERMINING THE COMPARATIVE NUTRITIVE VALUE

II. COMPARATIVE NUTRITIVE VALUE OF FOUR WILD FRUITS (GRAPE, NIGHTSHADE, ROSE, AND SUMAC)

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Professor Howard M.Wight

To the memory of the late Professor Howard M.Wight an acknowledgement is inadequate.

Words are not necessary to remember Professor Wight for he has left a memory and monument to himself in "his boys".The students of Professor Wight were considered as "his boys"and these boys will,in their work and spirit be a "living momument "to his memory and influence.

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II. COMPARATIVE NUTRITIVE VALUE OF FOUR WILD FRUITS.

INTRODUCTION

A great deal of progress has been made in determining the kinds and the amounts of foods eaten by wild animals, but practically nothing is known about the nutritive values of these various foods. With the steady development of wildlife management it is becoming more and more necessary that information on the nutritive value of foods be available if efficient rehabilitation of wildlife habitat is to be accomplished. The food that an animal eats is often largely determined by what is available during any given period. There are certain seasons when foods are normally present in sufficient quantities to meet the dietary needs of an animal, but in other seasons, such as the late winter and early spring, foods become scarce. It is for this critical period of food scarcity that wildlife management is attempting to supply and maintain an adequate amount of nutritious food for animals.

It is the intention of this report to describe a method of determining the comparative nutritive value of wild-game foods by an experimental procedure that does not involve the use of a large number of experimental birds nor the expenditure of a long period of time.

A statement often made in nutrition studies is that penned animals react differently to the same foods from normal, free-

It is not the purpose of this report to expand or investigate the complicated methods of the highly developed poultry nutritional studies, but rather its objective is to develop a simplified procedure that is a combination of the numerous standard experimental methods and the writer's own experience.

In the development of the experimental procedure, methods were drawn freely from the voluminous literature on the subject of poultry nutrition. There are three basic experimental methods in animal nutrition, which come under the following headings: 1, the group feeding method; 2, the individual feeding method; and 3, the paired feeding method. The group method was closely followed in this work and will be further elaborated from basic development to modifications made to fit the need of the problem.

Advice was obtained by corresponding with several of the recognized leaders in poultry and pheasant research work. With references from literature, personal communications, and precious experimental work, the study was planned and carried out with the specific purpose of determining the comparative nutritional values of wild foods. The problem resulted in a four-month study that involved four different stages of development. The first was the collection of the fruits to be used; the second, the development of an experimental procedure; the third, the physical testing apparatus, and last, the evaluation of the experimental results.

Studies in avian nutrition have almost entirely dealt with domestic birds, and it has been only in the past few years that any work has been done on the nutrition of wild game.

The study of procedures and results of previous investigations served as a guide for the interpretation of the experimental result

Review of the Literature

There have been many studies on the qualitative and quantitative food habits of birds and mammals, but, to date, only a start has been made to determine the actual sustentative or nutritive value of these various food items. Especially important and interesting is the knowledge of the nutritive value of the various wild foods that birds have resource to, for it is often the natural or exotic food shrubs that serve as important sources of food during severe and critical winter periods of food scarcity.

In direct contrast to the feeding habits of pheasant, in Michigan, where grains form about 74% of the year's food, Dalke (1933), is the small percentage of 34.54%, Wright (1941), grain eaten by pheasants in Rhode Island. To fill in this gap left by low cereal consumption of Rhode Island birds, wild fruits and seeds are an important in the food habits of the pheasant.

To determine methods of evaluating the nutritive value of wild foods, reference has been freely made to poultry nutrition studies, references of the food habits of wild pheasants, and to the few actual nutritional studies made on wild pheasant foods. In the following brief review, a survey of the pertinent studies will be made before going on to the actual experimental work.

Poultry Studies

From the wealth of poultry nutrition studies that have been made, several of the more important ones that bear on various chronological and developmental phases of the nutrition problem will be reviewed, for it is from these studies that the pheasant feeding procedure was largely developed.

During the period of 1912 to 1917 Hughes (1918) used chickens, pigeons, and rats in a study of the nutritive value of corn as a single food and showed thatthese animals were very susceptible to the inadequate diet that corn yielded. Roup, leg weakness, and production of eggs with low-hatchability were the results.

In 1928 Jull and Titus (1928) carried out a more detailed study of poultry feeds and based their final results on the growth of the bird in relation to feed consumption. From this study, it was apparent that for each successive 1000 grams of feed consumed, there is a proportionately smaller increase in weight gained.

Dunlop (1933) in a wide survey of nutritional literature, reveals only three methods of experimentation which have been used to determine the effect of a particular diet on the live-weight increase or growth of a species of animal. The methods that have been evolved are:

1. The group feeding
2. Individual feeding
3. Paired feeding

Of these various methods, a more complete explanation will follow in the methods of experimentation.

Payne and Hughes (1933) reported on an extensive study of the effect of inadequate rations on the production and hatchability of eggs, stating that the test birds on a 65% diet of yellow corn as the only source of Vitamin A gave the lowest fertility and hatchability. As shown in this study and many others, corn is a very good food but not a sufficient food in itself and must be supplemented with other food items in order to produce a balanced or adequate ration.

Titus, Jull, and Hendricks (1934), in a study of the growth of chickens as a function of feed consumption, found that, on a basis of relative food intake, the male chicken is the more efficient utilizer of food and hence can undergo more drastic undernourishment before showing symptoms of a nutritional deficiency.

One of the first experimental tests to determine the individual comparative nutritive value of various grains, was the work of Payne (1934) who studies the comparative nutritive value of sorghum grain, corn, and wheat as poultry feeds. Twelve hundred white leghorn chicks were started and raised to maturity on the test rations. The test rations were composed of a common basal ration to which was added an equal amount of the different grains to be tested, thus making the ration carry 50% of the grain to be evaluated. The final criteria of evaluation was based on a study of feed consumption, maintenance of body weight, egg production, mortality, and hatchability.

In 1936 Crampton (1936) made a review and analysis of published data relative to the feeding values of certain cereal grains and said, "Regardless of their apparent similarity nutritionally, the cereal grains are, of course, separate entities, each showing certain peculiarities. Most of the differences are in the mineral and vitamin portions of the feeds". This same situation may well be applied and considered in the wild fruit diets of the pheasants.

In the study of the comparative values of feeding experiments made in 1937, Maynard (1937) stated that comparative feeding trials gave a specific answer to the comparative over-all effect of the test foods but did not tell anything as to why one food was better than the other. Biological and chemical assays can in some degree show how a food is better but still does not always tell why.

Work by Platt in 1939 (1940) on the effect of restricting the cereal diet of pigeons to corn and wheat showed that pigeons on a strict corn and wheat diet produced fewer eggs, had a longer clutch period, and produced smaller squabs than did the birds on corn, wheat, and a supplement of Canadian field peas. However, there was no difference in fertility or hatchability of eggs, a direct contrast to the definite detriment of hatchability in poultry eggs, where the layers were subjected to inadequate rations.

The composition and quality of feed consumed by poultry was determined by Buckner, Insko, and Amanda in 1941 (1941) on the basis of chemical analysis of the food rations under test. The chemical analysis yielded a rough estimation of the qualitative differences in the foods and this viewed from a comparative basis, gives a fair indication of the qualitative value of the foods.

Scott and Payne in 1941 (1941) found that birds tested on a restricted diet were inferior breeders as compared with birds on an adequate diet. This study did not compare the nutritive value of any single food item of the rations but merely indicated the effect of an inadequate diet on reproductive ability.

This review of poultry literature, extremely brief as it is, touches only a few of the fundamental research facts but the ones that seemed most important to follow out in planning an experiment to determine the nutritive value of wild foods. Amounts of foods, test procedures, effect of rations of poor nutrient quality, the reaction of male and female birds to testing, methods of making comparative food tests both biologically and chemically have been reviewed and, as such, served as a basis for the development of the test procedures.

Pheasant Studies

Wild foods:

Results of the food habit studies of the pheasant have fairly well determined the kinds and amounts of various foods taken by the birds in different localities. From the results of the various food habit studies, and especially from the Southern Michigan work by Dalke (1937), the basal rations for the experimental feedings were developed.

Of the many pheasant food-habit studies made, the following references indicate the extent of natural feeding, especially of the cereal grains eaten. Swenk (1930), in Central Nebraska, found that the diet of 100 pheasants consisted of 76 per cent of cultivated grains, of which 67% was corn. In Michigan, Dalke (1937) found that cultivated grains formed 74% of the food of 352 ringnecks; with corn composing 33% and wheat 20% of the diet. In Pennsylvania, Bennett and English (1939) determined the fall food of pheasants to be 74% corn and associated weed seeds. In Minnesota, Fried (1940) reported that cereal grains composed 81.3% of the food of 515 pheasants.

In direct contrast to the above findings, a presentation of Wright's (1941) results in Washington County, Rhode Island, where cereal grains are relatively scarce, indicated that cultivated grains formed only 36.55% of the total food and of this, the corn percentage is 34.54%. The rest of the Rhode Island birds' diets are made up of seeds and fruits. There is a decided contrast in percentage of wild seeds and fruits in the diet of the eastern and midwestern pheasant.

Although wild fruits differ greatly in the percentage composition in the winter-diet of the pheasant they nevertheless, may be more important in the nutritional requirements of the bird than generally considered. In Michigan Dalke (1937) stated that "Wild fruits and nuts are eaten consistently, but the percentage is small--11.93%--largely since the habitats of the wild fruit-producing species are restricted to a relatively small proportion of the pheasant range". In a compiled average for the months of December, January, February, and March, the foods of the pheasant as found by Dalke (1933), Table I, indicates the following feeding habits for the winter months.

TABLE I

PERCENTAGES OF FOODS CONSUMED BY PHEASANTS

	DEC.	JAN.	FEB.	MAR.	AVER.
Cultivated grain	79.349	35.957	80.203	86.083	70.363
Wild seeds	18.791	4.480	16.751	2.893	10.728
Fruits & nuts	1.693	45.751	0.000	0.308	11.938
Insects	0.024	3.581	0.000	0.006	0.902
Grass & leaves	0.143	10.231	3.046	10.707	6.031
Misc. An. matter	0.000	0.300	0.000	0.000	0.300

Wheat and corn are the most important grains in the diet of the birds during the winter but the importance of fruit during periods of inclement weather and deep snow is indicated by the increased proportion of wild fruits in the birds' diet during such periods. Dalke (1937) stated, "Pheasants tend to frequent shrub areas and thickets during inclement weather and are consequently more closely associated, than usual, with wild fruits, particularly frost grape. In certain areas where frost grape was abundant, pheasants were observed feeding upon this source of food almost to the exclusion of other nearby foods, such as ragweed (Ambrosia) and burdock (Arctium)".

The importance of the various natural fruits taken by Southern Michigan pheasants during the winter, based on Dalke's (1937) crop analysis, is shown in the following Table II.

TABLE II

PERCENTAGE OF WILD FRUITS CONSUMED BY PHEASANTS

Fruit	% of Total of years food	% of Total Amount of Fruit Eaten
Grape (Vitis vulpina)	4.1	54.3
Pan. dogwood (Cornus paniculata)	0.4	5.3
Nightshade (Solanum Dulcamara)	0.3	3.9
Elderberry (Sambucus canadensis)	0.2	2.8

Wild fruits are taken consistently and their use is usually determined by their availability. If more wild fruits were available, it is probable that a higher consumption would voluntarily follow, not only because of availability, but because of physiological requirements for a well-balanced diet.

Review of Nutritional Studies of Wild Birds and Pheasants

One of the first actual nutritional studies with wild game bird foods was carried out in 1931 by Errington (1931). In this test, a series of pens of quail were fed various single kinds of wild seeds and fruits to be tested and checking weight reactions against a series of control birds kept on a ration of four parts corn to one part wheat. A check starvation pen was run to see the rate of body loss with no food available. Before putting the birds on the test, Errington (1931) determined what he calls the "provisional standard of weight", 200 grams, or what a healthy and well-fed quail should weigh. The foods used in this test were black locust (Robina), sumac (Rhus), rose hip (Rosa sp.), sweet clover (Melilotus), bittersweet (Celastrus), and grape (Vitis). From the final results, the conclusion was assumed that the specific foods or food combinations, except black locust seed, under the given conditions,of ad-libitum feeding did not keep quail at the physical level requisite for wintering.

In a review of the work done on the actual determination of the nutritive value of foods of the animal in the wild, only references will be made to avian studies as to type of study, results, and value.

Kendeigh (1931) in a study of the role of environment on the life of birds made the reference to their need of vitamins. These vitamin foods were needed for spring development of the gonads. Again, in another report Baldwin and Kendeigh (1932) stated that: "the normal body of an animal will compensate for low environmental temperatures by increased heat production and decreased heat loss". However, to meet such conditions, the bird requires a nutritious food supply for the ingestion of easily oxidizable food raises the body temperature, whereas lack of adequate food results in starvation and a progressively lowering of the body temperature.

Bissonette (1932) demonstrated that diet may modify the reaction of a starling (Sturnus vulgaris) to light. On a rich diet birds may be brought to full spermatic activity within 20 days, whereas birds on a restricted diet and under similar light conditions failed to even induce testis activity.

Along with the studies of the food habits of the wild pheasant, Dalke (1933) presented a figure showing the fluctuation of the various nutrient constituents of the pheasant's plant diet for the year-round period (Appendix). This report on the nutrient composition of the wild pheasant food, was made by analyzing the crop content material for each month and then computing the chemical composition from analysed plant foods of the same kinds. Data of food habits from which this information was derived made up only the plant food of the bird and as such, totaled 89% of the total food eaten, the rest, 11%, not analyzed, included mostly animal food.

Dalke's presentation of the gross chemical value composing the pheasant's diet is possibly the first attempt at such a study of the wild bird's nutritive intake.

In a generalized study, Dove (1935) stated that: "regardless of inate abilities to select foods, the individual is often limited in food selection by the variety of foods available". In a study of the effects of various foods upon the individual, Dove stated that "It can be shown experimentally that access to one set of foods, i.e., corn and oats alone,

will produce individuals so nervous that they run themselves thin and become excessively excitable and irritable, but when the same two foods are given with a third, the mineral calcium, the excitability is greatly reduced and life is prolonged. The whole physical, mental, and social status is closely associated with choice of food", or in other words, supplementary foods will make a ration that is "qualitatively complete and quantitatively sufficient".

Hosley (1936) in an evaluation of several woody plants for food and cover use by wildlife stated that: "We are still in the dark as to the nutritive value of fruits" and "we are just making a beginning on the important questions involved". In a tabular form, Hosley gave some of the available chemical analyses of nuts and fruits with that of corn and grasshoppers given for comparison and stated that: "These few analyses show that the materials covered are valuable foods for wildlife, when considered from the usual standard of chemical makeup. However, one of the greatest values of fruits to wildlife is apt to be through the vitamins or other special properties".

In 1936, Errington (1937) published his second series of experimental feeding results and this time with ring-necked pheasants and using practically the same foods as he did in his previous quail studies (1931). The experimental procedure was based on the field observational and experimental technique. The study was carried from January to April, 1933, with four to eight birds in a partially exposed pen. Fruit and water were freely available. All food was fed as single items and "ad-libitum". Weekly weights were taken of the birds. For control birds two males and four females were kept on yellow corn and green food for 62 days; a second series of controls consisted of birds that were starved. Test items were sumac , Rhus glabra, sweet clover, Meliliotis, giant ragweed, Ambrosia trifida, poison ivy, Rhus Toxicodendron, burdock, Arctium, velvet leaf, Abutilon sp., dock, Rumex sp., smartweed, Polygonum sp., buds and catkins and a mixture of all foods. Errington stated that; "the exclusive feeding of a single item of diet to animals may have questionable pertinence because of the effect of monotony of diet in bringing about weight losses recorded. It should be clear, however, that the experiments on a whole were planned to duplicate critical conditions found in the wild". From this study, the above author makes the distinction between "staple foods" and "emergency foods". The staple foods have the ability to keep birds in good flesh and carry them over the critical period, whereas, the "emergency foods" retard the rate of starvation by about one half of what it would be if the birds ate nothing.

Bissonette (1937), working upon the stimulating effect of red light on testis activity in the starling (Sturnus vulgaris), indicated that light exposure is not the only factor conditioning the sexual cycle of birds, for in some species, lack of certain dietary essentials may retard breeding and nesting activity until a high protein diet and certain vitamins are available for feeding the young in vitrio. The profound influence of diet upon reproductive rhythm and capacity is governed by the presence or absence of the vitamins and through general inanition from nutritional deficiencies of proteins, fats, and minerals. In general, it is the quantity and quality of nutrients that make for proper sexual functioning of birds.

In the 1939 Year Book of the Dept. of Agriculture, an attempt was made to show what has been done in the field of nutrition and feeding of gallinacious birds in the wild and in captivity. The nutritional differences between species is explained briefly in the light of the types of natural foods selected in the wild. Like all forms of animal life, the

pheasant has definite nutritional requirements, which may or may not differ in the wild from captivity, but these are essential in varying degrees so that a balanced diet may allow for proper growth, maintenance, and reproduction.

In determining the most economical diet to carry game-farm pheasants over the winter, Skoglund (1939) found that feeding a grain mixture of two parts coarse cracked yellow corn, one part of wheat, and ½ part of oats resulted in the best growth as measured by total gain and percentage gain in weight.

The evaluation of an adequate diet must take into consideration all materials that go into the diet of the bird, McCann (1937) studied the effect of grit on pheasant and was quite convinced that grit serves as a source of nutrients as well as a grinding agent in the digestive system of the birds.

It is well known that nutritious food is important in maintaining the proper body metabolism of animals during severe periods of weather and other periods of stress. Smith (1939) experimentally demonstrated that pheasant chicks that had been recently fed and had ready access to easily oxidizable food were able to withstand more exposure to cold and maintained a more normal body temperature than did experimentally starved chicks.

In 1940, Skoglund again reported on a feeding study made with penned ringnecks to determine the grain food selection of the birds under confined conditions and found that the birds regulated their diet as follows:

Grain	Per cent
Corn	36.79
Wheat	34.71
Oats	5.16
Barley	4.95
Buckwheat	6.65
Soybeans	11.75

In the winter of 1939, while at the University of Connecticut, the writer had occasion to make some preliminary nutrition studies and following somewhat the procedure used by Errington (1930) attempted to determine the comparative nutritive value of rosehips and barberry, using yellow corn as a basis of control.

Another study worked out by the writer (1941) was the theoretical development of a method for determining the comparative nutritive value of wild fruits.

The most recent published report on nutritional studies is by Hammerstrom (1941) and in this report, he states that the purpose was "to determine whether a diet of browse (buds and catkins) alone, in unlimited quantity and finely selected, could maintain the weight of prairie chickens (Tympanuchus Cupido americanus) in winter". The significant and expected finding of this experimental study was the affirming of the importance of grain in the birds' diet.

One of the more recent studies, made by Wright (1941) in Washington County, Rhode Island, attempted to make a nutritive evaluation of the foods eaten by quail and pheasants in the wild state. The study was very much like Dalke's (1933) for the individual food items were chemically analyzed and then an approximate composite analysis of items aggregating 99.6 per cent of the weight of the pheasant food for the months of November and December.

A non-experimental method of determination of nutritive value of fruits is the work by Wainio and Forbes (1941). The method used by these workers was an intensive chemical analysis of 25 species of fruits and 10 species of nuts that show promise as wildlife foods and can be encouraged in wildlife management.

The majority of nutritional studies with wild game birds have dealt with the evaluation of single items of food, and either derived results from weight reactions of single feedings or have attempted to determine nutritive values from chemical analysis. In this following study, the weakness of single-item feeding was partially overcome by working the test evaluations from a common basal ration. It was felt that diets deficient in the essential basal nutrients will not permit satisfactory comparisons of supplements, or test foods.

Of the various test methods and experimental procedures used in avian nutrition studies, there is no one procedure that can be used for the specific purpose of determining the comparative nutritive value of any given series of foods. To derive accurate results, a combination of methods, employing biological and chemical assays must be used.

EXPERIMENTAL PROCEDURES USED

Test Methods in Animal Nutrition

All basic methods in avian nutritional studies are derived from the poultry nutritionists who have made remarkable progress in this field. In a survey of the literature pertaining to poultry nutrition, there appear to be three general methods used to determine the effect of nutritional differences. These are the individual feeding tests, the paired-feeding test, and the group-feeding test.

Individual Feeding Test: The individual feeding test method, in its simplest form, has all the experimental animals in separate pens and thus has complete control over each individual, and, also the ability to regulate the food intake. The results can be handled as individual data and as such are much more reliable than averages derived from group studies. This method, however, involves the use of a large number of animals and an equal number of cages. A great deal of time must be spent in the care of the animals on such a test and also, the feeding is done on a controlled level of intake.

The Paired-Feeding Test: In the paired-feeding test method, the foods to be tested are fed to pairs of animals. One animal of a given pair is placed on the control ration and the other is placed on the test ration; both animals are given exactly the same amount of food.

Each animal of a test pair must be as nearly like the other as possible in age, size, previous history, and general physical condition.

The amount of food given is determined by limiting the intake oD both to that of the animal consuming the lesser amount.

The data obtained from this type of experiment is easy to handle statistically, but is open to criticism in that limiting the food intake below the normal level may defeat the very purpose of the experiment. In practical tests in which palatability and level of food intake are important criteria of the relative value of the rations, there is need for unrestricted food consumption, and the paired-feeding test does not permit this. This test is most useful in experiments that attempt to measure the specific effect of any one nutrient rather than the over-all effect of a food.

The Group-Feeding Method: The group-feeding method of studying the nutritional value of a food is the one that has been modified and used in this study and for the present will be only briefly described, for it will be expanded in more detail later in this paper.

In this method of study, the animals are grouped several to a cage and food is given "ad-libitum"* Animals which make up each test cage are selected for similarity of age, sex, physical, and physiological characteristics. This type of experiment does not allow for individual control nor does it yield quantitative data on small differences. This procedure is one of the simplest to follow from the standpoint of labor and equipment involved and still yields data of significant value. This group-feeding method is especially useful where palatability, level of food intake, and comparative over-all

*"Ad-libitum" - free choice of quantity at all times.

effect of the food in question are to be determined.

EXPERIMENTAL MATERIALS AND METHODS USED IN THE DEVELOPMENT OF A GROUP-FEEDING PROCEDURE

In the development of any nutritional experiment it is essential that the procedure be planned and conducted in a manner that will reduce to a minimum the number of variables and also the possible interpretations. To reduce the number of variables, it is necessary to extend control to every experimental condition that might possibly influence the reactions of the animals under test. It is also important that control and test animals be subjected to exactly the same experimental conditions except the one variable that is being studied. In the following description of methods and materials used, an attempt was made to describe each variable and other considerations that must be evaluated in the planning of a valid nutritional test.

Time of Year Test Was Made

The first consideration of a short-period nutritional study is the time of year to make the tests. From actual field research of food needs and physiological changes of the pheasant, it has been found that a test made from December to March is the most satisfactory. At this period of the year, climatic conditions are usually severe and thus the utmost in a food is required to supply the bird with the proper nutrients to help maintain normal body heat and general maintenance. Increased coldness results in an increase of body metabolism with the resulting increased demand upon the food to supply the heat energy necessary to maintain the normal metabolism of the tissues.

Aside from the general requirements of maintaining the body at a normal temperature, the increased physiological changes occurring within the reproductive system of the bird, require food of a high nutritious level. It is at this period of the year that the birds are changing from the premating-phase to the active reproduction-phase.[1] With the increase of physiological activities and the severe climatic conditions the birds must cope with, it seems quite apparent that the period from December to March is the ideal one to test the nutritional value of a food.

Cage Construction and Location

It is an important consideration in the test procedure to have the holding pens built and located correctly so as to facilitate the handling and welfare of the birds. Of the many considerations in the building and location of the test pens, the following items were considered:

1. Size of Cages: The size of the cages depends upon the number of birds to be held and a good rule is to allow 6 to 8 square feet per bird.

2. Construction of Cages: The proper construction of the pens is important for it facilitates the handling of the birds, the sanitation, and the general welfare. The construction

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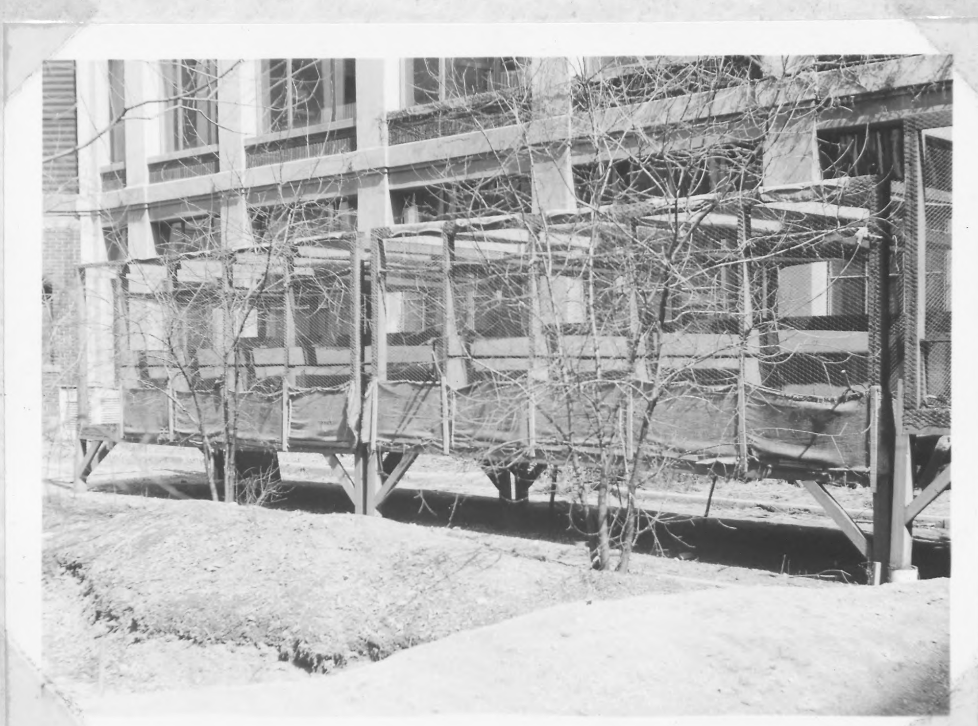
[1] H. M. Wight, "Life History of the Pheasant in Southern Michigan". Unpublished manuscript, University of Michigan (1941). Pp.147.

of the test pens are as follows:

A. The cage had fish netting tops to prevent injury to the birds when they fly about; the sides were of fine chicken wire.

B. Bottoms of the pens were of one-half inch mesh hardware cloth, and below this wire floor, a heavy burlap was fitted to collect droppings and to prevent underdrafts.

C. Burlap was hung around the lower foot or so of the sides so the birds would not frighten easily.



3. Location of Pens: The location of the test pens is worth quite a good deal of thought, for this determines the amount of exposure the birds will receive. Three considerations should be made in the location of the pens:

A. It was important in this test procedure to keep the birds exposed to normal weather conditions. Weather and temperature changes influence the activity of the animals and it is, therefore, necessary that they be subjected to the natural weather changes.

B. Normal exposure to sunlight is important to the health of the birds and they should be allowed all the sunlight possible.

C. Birds must be protected from molestation for otherwise they may stop feeding, and will often injure themselves when strangers appear or other influences frighten them and they fly blindly about the cage.

Feeding Equipment

In a study where weight as related to food consumption is a necessary criterion for evaluation, it is most important that the food intake be accurately determined. It is simple enough to keepcontrol of the amount of food fed to the birds, but it is not an easy task to account for wastage and spilled food. To overcome this situation, it was necessary to use spill-proof and weather-proof hoppers with catch trays underneath.

Selection of Test Birds

Birds that were used as test subjects were selected three weeks before the start of the experiment. This period might be called the "conditioning period" for it allowed the birds to become accustomed to their new surroundings, but what is more important, it allowed the selection of uniform birds. The selection of test birds involved the following considerations:

A. Birds selected for test purposes were of the same genetic origin and had been raised to maturity under similar conditions.

B. Birds were of approximately 8 months of age and were just reaching their first reproductive season. The utilization of birds of this age minimized the variable of growth requirement and stressed maintenance.

C. The weights of the birds in any test pen should not vary by more than 10 to 15 per cent from one another. The total average weights for all test pens should agree within the 10 to 15 per cent limit, but this was not strictly adherred to because of uncontrolable circumstances.

D. It appears that in experiments involving small numbers it is best to use birds of one sex. Male birds are known to utilize their food better than hens, but the female is more reactive to food changes. During the period from December to March when the tests were made, the hen is undergoing rapid sexual maturation, and a highly nutritious diet is required; otherwise reproductive capacities may be hindered. Similar physiological changes are taking place in the male bird, but the effect of a poor diet on the reproductive capacity of the male does not have any noticeable effect within a period of four months.[1]

E. The birds that were selected were as nearly alike in temperament and physical characteristics as possible. Diseased and sick birds were rigidly culled.

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[1] Adamstone, F. B. and L. E. Card. The effect of vitamin E deficiency on the testis of the male fowl.

F. There were from four to five birds per pen. The number of birds to use in any test is dependent upon the facilities for handling them, but the larger the number o of test birds the more reliable the results will be.

The fewer the birds used, the more nearly alike they should be in physical and physiological characteristics.

SELECTION AND PREPARATION OF DIETS*

The determination of what foods are to be evaluated depends entirely upon the investigator and his purpose in mind, so no statement will be made other than the simple fact that if it is a winter-study, it is necessary that foods be used that are naturally available for this time of the year.

Collection of Fruits: The collection and storage of the fruits was important consideration. It was found that after the first heavy frost, most fruit was in condition to be picked. Fruits that were persistent were not picked until later in the season for it is better that they be kept in a natural state.

Storage of Fruits: Fruits that are available to pheasants during the winter have been subject to all the varying climatic conditions and this has a direct influence upon their nutritional content.[1&2] All foods that were collected in the fall were exposed to normal weather conditions by storing the fruits on wire trays outdoors.

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* See Appendix for complete rations.

[1] Hellmers, H. "Variations in nutritive value of deer foods" Journ. of Wildlife Management, Vol. 4(3). 1940.

[2] Influence of diet on the gonad activity of the English Sparrow J. C. Perry. Proc. Soc. Exp. Biol. & Med. 38(5).

Derivation of the Test Diets

The preparation of the physical equipment, the selection of test birds, and the collection of fruits to be tested was a minor problem in comparison with the task of preparing the control and test diets.

The developing of a control diet simple enough in composition but still able to furnish the birds with an adequate supply of nutrients was the first problem to consider. To provide a basis for the control ration, data were taken from the food habit studies of wild birds and also from experimental feeding studies.

Dalke (1933) working on the winter food habits of pheasants in Southern Michigan, found that grains made up approximately 70 per cent of the bird's food.[1]

TABLE III

FORMULA FOR CONTROL FOOD

FOOD	PERCENTAGE
Yellow corn	54.50
Wheat	40.00
Meat scrap	5.25
Salt	0.25
	100.00

[1] P. D. Dalke, "Food habits of pheasants in Michigan based on crop analysis," Ecol., Vol. 18, No. 2 (1933). Pp. 194-213.

A study by Fried (1940) in Minnesota, indicated that for this same period of the year, grains made up 88 per cent of the pheasant's food. The remaining percentage in both mentioned food studies was composed of wild seeds, fruits, nuts, insects, grass, leaves, and miscellaneous matter.

In a study carried on by W. C. Skoglund (1940) pheasants were allowed to select what grain they wanted, and the final results showed that corn and wheat were taken in almost equal proportions, whereas other grains were taken only in small quantities.[1]

A control ration, illustrated in Table III, was developed from the data available in food habits studies and from Skoglund's (1939 & 1940) experimental feedings. The control ration, illustrated in Table III is composed of a higher proportion of corn and wheat than wild pheasants are normally accustomed to eating. This proportion is necessary because of the simplicity of the ration and the use of only two basic grains. Meat scrap and salt were added to supplement the animal and mineral foods that the birds would normally pick up in the wild, or receive if they were fed a complete diet.

In the preparation of the basal ration, to which the test food was to be added, somewhat the same procedure was followed as in the development of the control ration. Dalke's work (1937) on the food habits of pheasants in Southern Michigan, was followed closely. Table IV shows the percentage of various

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1 W. C. Skoglund, "Self selection of fall and winter foods by ringnecked pheasants", Penn. Game News, Vol. II, No. 7 (1940). Pg. 7.

foods eaten by the birds during the four winter months. It is from this table that the basic ration was developed.

TABLE IV

PERCENTAGES OF VARIOUS FOODS EATEN BY WILD PHEASANTS DURING THE WINTER[1]

FOOD ITEM	DEC.	JAN.	FEB.	MAR.	AVERAGE OF 4 MONTHS
Cultivated grains	79.35	35.96	80.20	86.08	70.10
Wild seeds	18.79	4.48	16.75	2.89	10.75
Fruits	1.69	45.75	0.00	0.308	11.93
Insects	0.024	3.58	0.00	0.006	0.90
Grass and leaves	0.143	10.23	3.05	10.707	6.03
Misc. matter	0.00	0.00	0.30	0.00	0.003

This table indicates that the cultivated grains are the bulwark of the wild pheasant's winter food, and, therefore, it was decided that the basal ration should be made up of a relatively high proportion of grain, but the amount should not be too high to mask the cumulative nutritional effect of the test fruit. Table II indicates that fruits comprise an average of 11.93 per cent of the winter diet. In the experimental work, the object was to determine the comparative food value of the fruit, and to do this it seemed logical to subject the

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1 P. D. Dalke, "Food habits of pheasants in Michigan based on crop analysis", Ecol., Vol. 18, No. 2 (1933). Pg. 205.

birds to a decreased grain ration and an increased fruit ration. The proportion of test food to basal ration that should be fed, depends largely upon the simplicity or the complexity of the experiment. The ideal procedure would be to test each of the fruits at different levels, but this method involves a great deal of work. From personal communications received from several men engaged in poultry or pheasant research work, recommendations for substitution ranged from 5 to 50 per cent for diets of one level.[1,2, & 3] The final proportion determined was 35 per cent test food and 65 per cent basal ration; this proportion approximated the grain eating level of the wild birds. Table V illustrates the composition of the basal ration.

The ratio of test food to basal ration is largely a matter of judgment, but some help may be had by a study of the food habits of the wild birds as illustrated in Table IV.

To determine the effect of fruits in the diet of the pheasant a more drastic measure was resorted to, and that was to greatly increase the proportion of wild fruits in the diets of the birds. As the test was conducted, there were duplicate pens of each test series and up until the sixth week each pen

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1 S. W. Callenbach, Dept. of Poultry Husbandry, Penn. State College. In a personal letter dated November 29, 1940, recommended a substitution of 5 to 20 per cent of test fruit.

2 C. H. Schroeder, Director of Poultry Research, Larro Research Farms, Detroit, Michigan. In a personal letter on November 30, 1940, recommended a 50 per cent substitution of test fruit.

3 W. C. Skoglund, Dept. of Poultry Husbandry, University of Delaware. In a letter dated November 22, 1940, recommended a 30 per cent substitution of test fruit.

TABLE V

COMPOSITION OF BASAL RATION AND TEST FOOD

BASAL FOOD	AMOUNT BY PERCENTAGE	TOTAL COMPOSITION OF BASAL AND TEST RATIONS
Corn	19.75	
Wheat	10.00	
Meat scrap	2.50	
Salt	0.25	65 per cent
TEST FOOD		
	35.00	35 per cent
	100.00	100 per cent

of duplicates was fed the same test diet. From the sixth week until the end of the experiment, one set of each of the duplicates was subjected to a reversed diet or one that was 65% fruit and 35% basal ration. This ration of foods was known to be out of proportion but it was felt that it should be this drastic if any significant physical or physiological reaction could be expected in the short time left for the study. Table VI illustrates the composition of the reversed test diet.*

* See appendix for results of this reversed test diet.

TABLE VI

COMPOSITION OF 65-35 BASAL RATION AND TEST FOOD

BASAL FOOD	PERCENTAGE	TOTAL COMPOSITION OF BASAL AND TEST RATION
Corn	19.5	
Wheat	10.0	
Meat scrap	5.0	
Salt	0.5	35 per cent
TEST FOOD		
	65.00	65 per cent
	100.00	100 per cent

Preparation of Final Test Diets: Having decided upon the proportions of test food to basal ration that was to be used it was necessary to get accurate proportions of the ingredients in the food mixture. The basal grains are in a semi-dry condition whereas the fruits that were stored outdoors still have a high moisture content. To bring the moisture level of the fruits down to approximately the level of the grain, it was found that placing the fruits indoors at room temperature for two weeks removed enough water to make them comparable in moisture content to the basal grains.

After the fruits had dried sufficiently, it was necessary that all woody stem and foreign matter be cleaned from them. When the fruits were relatively free of foreign matter, and at a low moisture content, the basal grains and test fruits then not be measured on an air-dry and pound for pound basis.

After the test and basal foods were mixed in the desired proportions, it was necessary to determine a method of presenting the feed to the birds so that they would eat it in the desired proportions. In a mixture of whole grains and fruits, the birds would show preferences for a certain grain or fruit. To overcome the tendency of food preference, the mixtures were prepared in a mash form so that the birds could show no preference when selecting their food.

All grains used in this experimental method were procured and ground at a local grain mill. The grinding was done by two different sized grinding screens. The basal grains were ground on the "fine" screen and the fruits on the "medium" screen. This two-type grinding resulted in a more even-textured mixture of feed than did a grinding with the "fine" or the "medium" screen alone. After the grain and the fruit was ground, meat scrap and salt was added and then all of the ingredients were thoroughly mixed.

The feeding of adult birds on a mash diet may seem to have been a questionable procedure to follow, for mash is usually considered as a food only for young birds, but there was no other alternative except preparing the mash in pellet form.[1] The only advantage of feeding the birds with pellets would be that solid food would be available, but bulkiness of food would have no effect upon the final results of the diets.

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1 Pellets are made by forcing damp, mash foods through the holes of a die and then dried to the size of a small pea-bean.

Pheasants normally grind their food to a mash form and thus there is little danger of increasing the digestibility because of the ground condition of the food.[2] In a personal communication, E. W. Callenbach (1) of Pennsylvania State College, stated that the only effect that a prolonged mash diet might have upon adult birds would be to decrease the size of the gizzard after a long period of such feeding.

Supplementary Foods

With the control ration and the test ration prepared and ready for use, the next item considered was the use of the supplementary foods. These foods, water, grit, and green vegetable matter, are not ordinarily thought of as specific foods, but each one is absolutely essential in the normal diet for the function or functions that it performs.

Water: Water is a food of extreme importance in the physiology of any animal, and it is essential that an adequate supply be available at frequent intervals.

Grit: The use of grit by pheasants is considered to serve a dual purpose: first, to provide roughage to aid the gizzard in the grinding and crushing of food, and secondly, to supply the body with minerals.

Recent studies made by L. J. McCann (1937), on the grit requirements of pheasants, proved conclusively that common glacial gravel supplied the birds with an abundance of the

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[2] See report by Swank (6), Personal Correspondence.

minerals that are essential to health.[1] If a grit material that does not furnish the mineral elements essential to the diet of the birds fed, structural and functional injuries occur within a period of two weeks. From this data, it was thought that a liberal supply of native glacial grit would best meet the roughage and mineral requirements of the birds.

The grit was supplied in separate hoppers and an abundance was available at all times.

Green Food: The use of green vegetable matter is very important in the diet of a pheasant. From green foods, the birds derive minerals, nutrients, and vitamins that other foods do not supply. A review of Table II indicates that grass and leaves amount to 6.03 per cent of the average winter diet. When snow covers the ground for any length of time, the birds cannot get at green foods, but whenever the grass, or other leafy material is available, they eat it consistently. Winter wheat, clovers, and green-manure crops form the supply of green food during the winter, and such foods are usually available on every pheasant range.

Almost any green leafy food can be given the birds to supplement their natural diet. Lettuce and cabbage were found to be very satisfactory when fed twice a week; each bird receiving about an ounce of greens at a feeding.

In the feeding of the three supplementary foods, no control of quantity or quality was made. It was assumed that

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L. J. McCann, "Studies of the grit requirements of certain upland game birds", Journ. of Wildlife Management, Vol. 3, No. 1 (1937). Pp. 17-38.

all birds would be subjected to the same conditions and the influence of variables would be insignificant.

Feeding Methods

With the control and test foods prepared and the birds selected for the test, the actual feeding was begun. In this simplified experimental method, only a basic set-up is used with duplicate pens of each test food. Figure 1 illustrates diagramatically the physical testing plant used in the experimental study.

Five duplicate pens are illustrated. One, a control unit and the others are the test pens.

The birds were fed once a day and given more food than they would normally consume. There are numerous arguments about the weakness of this "ad-libitum" feeding, but it was decided that this method would be the most natural, and, also, most practical in this test. Wild birds are not usually limited to a constant low level of food intake and normally feed until they are satisfied.

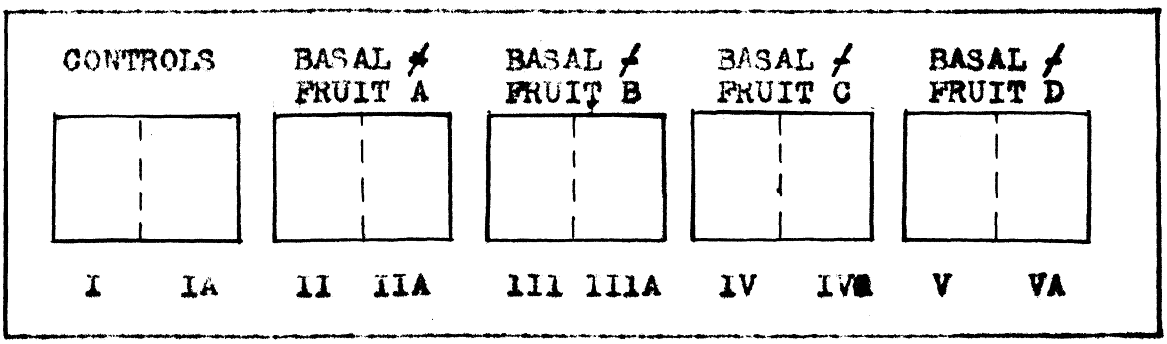

Figure 1. Diagrammatic plan of the physical testing plant showing how each pen is divided up into duplicate compartments and how the numbering system is used. Four birds in each compartment.

Differences in the level of food consumption may be caused by the individuality of the animal or by the difference in desirability of the food. A larger amount of food may be consumed in some test diets because of the inferiority of the nutrient content, hence the need of a larger quantity of food to supply the necessary food elements. In direct contrast to the poor food, a diet may have a stimulating effect upon hunger because of its high nutrient content and ease of utilization.

The nutrient content of a food is not the only consideration to evaluate when levels of food intake are different. Past experience, environment, and genetic makeup of the individual have a strong influence on the quantity of food that will be eaten. To overcome all the variables that cause individual differences in level of food consumption, the "ad-libitum" method of feeding was considered to be the most important.

EXPERIMENTAL RESULTS OF FRUIT EVALUATION

Weather and Temperature:

In the determination of experimental results, one factor that exerts an important influende but that is difficult to evaluate is the effect of weather conditions. This test was purposely planned so that the feeding trials would coincide with the "critical period" or the months of January, February, and March. It is during these months that the pheasant's food supplies are often limited and the birds must resort to whatever is available in order to maintain themselves.

During the months of January, February, and March, 1941, the weather conditions at Ann Arbor, Michigan were not as severe as the average past winter. In this study temperature was considered the most important of the climatic factors because of the fact that the birds were caged, snow depth or amount did not affect them in any way. A continuous record was kept of temperature by the use of a Friez Hygrothermagraph that was located at the side of the experimental pens.

Results obtained from the recorder were handled in two ways. Table VII gives a tabular summation of the mean and minimum temperature for the duration of the test period.

The second method of indicating temperature will attempt to show the mean temperatures for the two daily periods of physiological rhythm in the body temperature of the bird, the daylight period of activity and the night period of relative inactivity. Figures for this method of temperature presentation were derived by breaking the 24 hours of each day into actual periods of light and darkness and then determining

TABLE VII

MEAN AND MINIMUM TEMPERATURES-FEB.-MAR.
°Fahrenheit

PERIOD	JAN. 20-25	JAN. 26-31	FEB. 1-7	FEB. 8-14	FEB. 15-21	FEB. 22-28	MAR. 1-7	MAR. 8-14	MAR. 15-21	MAR. 22-28	MAR. 29-APR. 5
MEAN TEMP.	24.7	25.5	25.2	29.1	19.1	21.2	25.0	31.3	25.0	31.0	37.5
MINIMUM TEMP.	18.5	19.5	14.0	17.5	10.0	13.0	17.0	23.0	9.5	21.5	22.5

the maximum, minimum, and mean temperature for each period. The hours of daylight and darkness were divided as follows:

	BEGINNING OF TEST	END OF TEST	HOURS DIFFERENCE
Hrs. of dark	14.18	11.06	3.12
Hrs. of light	9.42	12.54	3.12

Reference to figure 1 shows the mean temperatures for the periods of darkness and light given as solid and dotted lines and the maximum and minimum ranges are indicated by extensions from the mean.

For the duration of the test period there were very few periods of extremely low temperatures and also the daylight and nighttime mean temperatures were not widely different. In general, it may be said that the birds were exposed to a fairly mild winter.

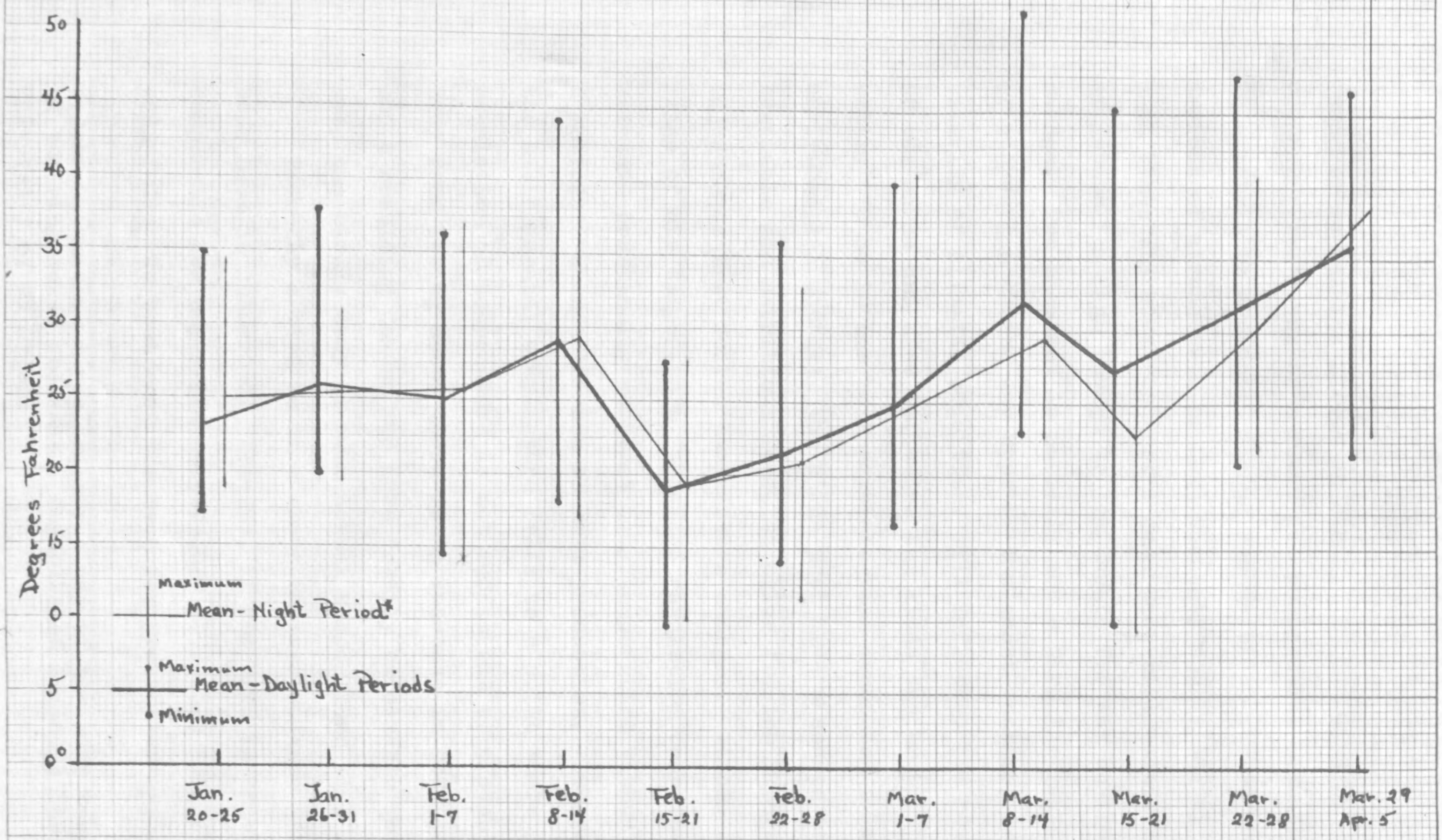

Figure 1. Weekly Mean Temperature And Ranges

* Hours of Daylight and darkness computed from the Neutical Journal were based on the offical period of sunrise and sunset progressively from Jan. 7 to April, 1941.

Temperature and its Effect on Birds: In the determination of the nutritive value of a food, it is essential that the food in question be evaluated during the critical period or during periods of stress such as food scarcity and coldness, for at such times the bird requires a fuel that will maintain a rate of metabolism high enough to compensate for any environmental change. The pheasant is normally not a bird that dies because of starvation during any type of inclement weather, but the severity of climatic conditions will influence the movements of the birds and also influence the kinds and amounts of food eaten. To be in the best physiological condition to meet any environmental changes, the birds must have a source of readily available and nutritious food, to allow fod the internal adjustments that follow temperature changes. Within a certain range of air temperature, physical regulation operates to maintain practically constant body temperature without requiring a noticible change in rate of heat production. However, if the environmental temperature falls to a point where physical regulation of temperature is not sufficient to prevent the body from losing heat, there is an increase in body metabolism and a resulting demand for more readily oxidizable foods to keep the bird's body at near normal temperature (103°F.).*

Normally a bird is in a state of near balance insofar as body heat is concerned. However, if the bird is unable to compensate for any rapid temperature drop, its body temperature will fall. To best meet the need for protection against temp-

* John R. Smith. A preliminary study of the body temperature of the ringnecked pheasant. Unpublished Master's Thesis. University of Michigan.

erature changes, an adequate diet is essential. Smith (1939) in an experimental study of the body temperature of pheasant chicks, demonstrated the fact that underfed chicks were unable to maintain normal body temperature even when exerting muscular activity; well-fed chicks showed a drop in body temperature but soon regained the original loss and suffered no visible discomfort at a low temperature.

Pheasants exhibit a daily rhythm in body temperature, Smith (1939), and show normally high temperatures during the day and low body temperatures during the might. It is therefore quite evident that the night air temperature and duration of darkness is the most important factor involved in the effect of low temperature on pheasants. To somewhat compensate for the lower body temperature at night, the expenditure of energy is less and consequently less body fuel is needed by the bird.

<u>Seasonal change in weight</u>: In general, birds attain their greatest weight during the winter, Kendeigh (1934), because of freedom from activity of reproduction and moulting. Wight (1941) states that during the months of January and February, the months of the most severe meterological conditions in Southern Michigan, male pheasants lose weight -- possibly because of the physiological changes that are taking place prior to the breeding phase. A factor that may be involved in giving resistance to quick temperature changes is a more active endocrine system (Kendeigh, 1934).* The increased

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* Kendeigh, S. C. Therole of environment in the life of birds. <u>Ecological Monographs</u>, Vol. 4(3). Pp.

involuntary activity of the endocrine system allows for a greater increase in the rate of metabolism when necessary for greater heat production in the body.

At medium winter temperatures the necessity for rapid metabolism is avoided by the substitution of an insulating coat of feathers and fat in the bird. It is only during of unusually low air temperatures that the rate of metabolism need be greatly increased. It is the combination of low temperatures and long periods of being without adequate food that causes this "critical period".

Handling prior to and during test period: The test birds were received on December 28, 1940 and placed in the various pens entirely at random. From this date until January 16, 1941 (3 weeks)the birds were all fed the following ration:

Corn.............54.50%
Wheat............40.00%
Meat scrap....... 5.00%
Salt............. 0.50%
Greens........... 3.00%

For three weeks all birds were fed this same ration with the purpose in mind of having the birds fo through an "initiation period" in which they would become accustomed to their new surroundings and also have the same kind of food for a period before starting them on the various test diets.

This period of "initiation" also allowed for the selection of the various birds that were to be used in each test pen. Birds were originally selected on the basis of weight and apparent temperament. However, this did not work too well for some of the birds exhibited a high degree of nervousness and excitability so they had to be shifted about thus upsetting the balanced weight selections.

Actual feeding of the test diets began January 19, 1941. The birds were attended once each mid-afternoon.

Each test pen was made up of 3 birds or a total of 6 birds per test for there were duplicate pens of each test. The two control pens contained four birds apiece. In either test or control birds, if the original number of animals did not complete the test because of accident or other reasons. Any bird that did not complete the 11 weeks of the test was counted out of the average results but his behavior up until he dropped out was evaluated to see the similarity of reaction. The actual feeding of the test diets began on January 19, 1941 (Week 1). Control and test foods along with grit, and water were fed ad-libitum. Green foods were given 2-3 times a week and consisted of cabbage or lettuce leaves.

Original weighings were made the day prior to the start of the test feedings (January 18, 1941) and then once a week thereafter. The end of each test week was culminated on a Saturday and then the weighings were made after dark, for at this time the birds could be handled very easily. All the birds of each pen were taken out and weighed within a period of ten minutes; each bird was put into a weighing-sack where it was held firmly and safely. The weighing-sack was made of flour sacking and was funnel shaped.

The birds were weighed on a gram scale that was accurate to one five-hundredth of a gram.

At the time of weighing of the birds, the food trays were removed from each pen and the surplus food removed and weighed. Each week's actual food consumption was carefully recorded. Along with each day's feeding procedure notes were taken of the general condition of the birds such as activity, fighting, sickness, plumage changes, and anything else that seemed useful to complete the records.

The final results of the comparative nutritive value of each of the four fruits will be evaluated in the following text where each study phase will be discussed in some detail and conclusions then drawn from the data presented.

Mortality: During the eleven weeks period of the test feedings, no deaths of birds can be directly attributed to nutritional deficiencies in the various foods eaten, although there may have been deficiencies of vitamins and other food elements that were not evident in this short-period feeding trial.

There was one death among the control-grain birds and that occurred on the 4th. week. This bird that died was severely pecked on the head during the 3rd. week of the trials, it was then removed from the test pen and put into a separate pen where it died a few days later. An autopsy performed by a disease specialist reported hemorages of the brain and also lesions on the left lung that were determined to be an Aspergillos infection.*

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* Autopsy by Dr. E. C. O'Roke.

Another bird on the control-mash test was found in the second week to be acting very listless, the bird's legs appeared weak and its eyes were dilated and turned. This bird was isolated for over a week before being autopsied. The autopsy revealed no visible pathological lesions.

One bird on the grape-diet escaped at the end of the 6th. week and was killed by flying against a brick wall.

Also on the 6th. week one bird on the nightshade diet was so severely pecked that it was taken out of the test pen.

Severe peckings was noticed on about the third week of February and by the first of March, two of the birds had to be bill-clipped to prevent them from injuring less militant birds.

Experimental Weight Reaction: The gain in weight of an animal during its growing period is commonly taken as a measure of the nutritive value of the food consumed and in this study, weight reaction of the birds to the various diets will be used as a partial citerion, along with food consumption reaction, and chemical analysis, in the comparative food evaluation of the fruits.

Wight (1941) stated that "the weight of a pheasant at any time, or during any period, when compared with the expected weight in the sex for that period should provide an index to the bird's health at that time or period and should give evidence of a high or low resistance. It further affords a means of obtaining evidence of the effect of certain environmental conditions such as prolonged hunting, migration, severe weather, and lack of food and cover"*.

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* Wight, H. M. Unpublished Manuscript. University of Michigan.

Another fact that is almost entirely disregarded in the weight reactions of most food studies of the pheasant is the seasonal variation in weights of the adult birds. Unpubl ished work by Wight (1941) states that there is a cycle of four major phases that adult pheasants go through and the body weight is closely related to each of these four physiological stages. Each of the four stages is a phase of the reproductive cycle and is designated briefly in the following table.

TABLE VIII

THE FOUR MAJOR PHYSIOLOGICAL PHASES OF THE PHEASANT *

PHASE	PERIOD	PHYSIOLOGICAL CHANGES	WEIGHT VARIATIONS IN WILD BIRDS
I	July	Moult	
	August	Decrease in size of sex organs	
	September	Change in temperature	1231 grams
II	October	Dormant condition of sex organs	
	November		
	December		1321 grams
III	January	Marked increase in size of sex organs	
	February		1275 grams
IV	March	Active breeding season	
	April		
	May		
	June		1347 grams

* Permission of the author H. M. Wight.

As table VIII shows, phase three and part of phase four need be considered for thyy overlap the period of the food study. During this phase, the birds start to undergo a very distinct physiological change relative to reproductive maturation, and may lose some weight. However, after the initial stimuli have reacted during this premating phase and the reproductive functions are activated, the birds then enter the fourth, or active breeding phase. It is during the beginning of the active breeding phase that a rapid increase of body weight occurs and the birds, both male and female, attain their heaviest weightsof the four phases of the year.

With this enlightening information of Wight's, it further complicates the evaluation of the comparative nutritive values of the test foods by comparative weight reactions for as it is clearly indicated, weight changes may occur independent of food conditions or types of food consumption.

Weight Reaction: Weight changes were followed very closely and weekly weighings were carried out to determine any changes. Each group of birds is treated as a whole and results reported as averaged for each group. Although the test groups of birds were originally picked for similarity of weight, compilations and final weight results differed widely and therefore more value should be put upon percentage gain or loss in weight rather than on actual weight gain or loss in grams.

Table IX gives the actual average gain in weight and the percentage gains over the original average "initial weights". The results as recorded in Table IX show that the birds in the

TABLE IX

AVERAGE DIFFERENCES IN WEIGHTS (GRAMS & PERCENTAGE) FROM THE FIRST THROUGH THE ELEVENTH WEEK OF THE TEST PERIOD

RATION	NO. OF BIRDS	WEIGHTS INITIAL	MAXIMUM	FINAL	% WEIGHT GAIN OVER ORIGINAL WEIGHT	WEIGHT AT END OF 11 WEEKS
Control Mash	7	1428.0	1428.0 (5th. week)	1396.0	- 2.24	-34.0
Control Grain	7	1252.6	1299.0 (10th. week)	1286.6	+ 2.71	+34.0
Grape I	6	1429.0	1633.0 (10th. week)	1583.0	+10.77	+154.0
Rosehip II	7	1329.6	141446 (8th. week)	1379.0	+ 3.71	+49.4
Nightshade III	6	1295.0	1376.6 (8th. week)	1356.0	+ 4.71	+61.0
Sumac IV	7	1364.5	1458.0 (7th. week)	1414.0	+ 3.62	+49.5

* Per-cent of initial weights at beginning of experiment.

control mash group never went beyond their initial average starting weight and ended up the 11 weeks of the test period weighing less than when they started it. The average loss for this group was -32 grams or a loss of -2.24 per cent from the initial weight.

*

Percentage gain/loss is derived from the "initial weight", or the weight of the birds the day they started their diets.

In the second series of controls (whole-grain) the birds ended up the trial period with a gain of 34 grams or a 2.71 per cent gain.

Group I (grape diet) birds reached a maximum average of 1603 grams on the eighth week of the test and then ended up with a gain of 154 grams or 10.77 per cent above the initial weight.

The results of group II (rosehip diet) shows that the maximum average weight attained was 1414.69 grams during the eight week. The final average weight was a gain of 49.4 grams or a 3.71 per cent gain over the initial weight.

Group III (Nightshade diet) birds reached a maximum average of 1376.6 grams on the eighth week. The final average weight reaction was a gain of 61 grams or a 4.71 per cent gain over the initial weight.

The final test series of group IV (Sumac diet) reached a maximum of 1458 grams on the seventh week. The final average weight difference was a gain of 49.5 grams or a 3.62 per cent above the average initial weight.

For a graphic representation of the weekly percentage weight changes, Figure 2 shows the weekly variations in each of the control and the test diets.

The material presented in Figure 2 illustrates the progressive average percentage changes in the body weights of the birds on the various diets. Just as in Table IX the comparative results may be drawn from the final results at the end of the eleven weeks of testing. Dunlop (1933) stated that in experimental studies a difference of 10% in body weight does not

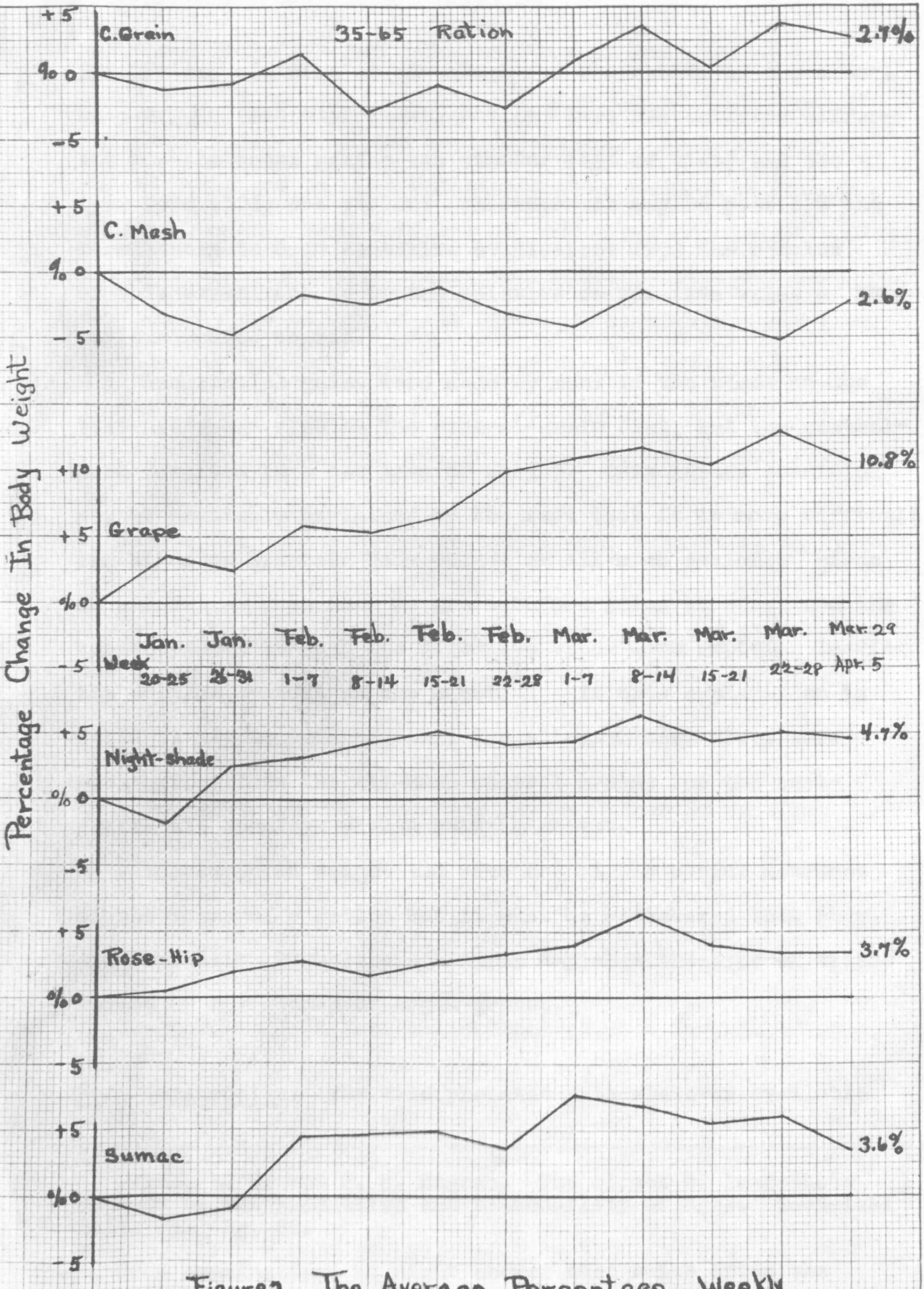

Figure 2. The Average Percentage Weekly Change In Pheasant Body-Weights

justify any claiming of advantage for one ration or the other. However, in this experiment, rations were not entirely different for the basal ration was similar (65% of diet) and the test food (35%) was varied; therefore it may be possible and permissable to draw tentative conclusions from the results of this experiment as to the relative comparative value of the various fruits tested.

Substantial gains were made by most of the birds on the test diets and also on the control-grain diet, but the control-mash resulted in a net loss of weight. This latter condition may be partially explained by the fact that it is more difficult for birds to maintain body weight on all-mash rations; birds do not eat as much mash as grain before going to roost and the former passes through the digestive tract more rapidly, leaving the crop empty most of the night.[1 *] If this explanation is valid it may be inferred that the all-mash test diets were much better than the all-mash control grains for the test-fruits all ended up with a gain in weight.

Increases in weight and size are highly useful measures of the value of a ration but it must be remembered that they are obviously incomplete and in no way show the type of tissue formed or any record of organ growth.

<u>Food Consumption</u>: The wild pheasant eats whatever available

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1 Payne, L. E. and J. S. Hughes. The effect of inadequate rations on the production and hatchability of eggs. Technical Bull. 34. Pg. 52.

* Crop examinations at night showed that quite often the pheasants did not have full crops when going to roost.

feed best suits him but under the experimental procedure it was necessary to limit quality and quantity of food items to the basal ration plus the test supplement. In the study of weight reactions it appeared that the variations in average weights may have been a result of feed consumption. Each diet was made up of a similar basal ration but a different test supplement, the effect of the different supplements may have been strong enough to cause the variance in total food consumption and also in the food - efficiency or the ability of the food, per-unit consumed, to produce an equal unit gain in body weight.

Rations: The fruits to be tested, grape, rose-hips, nightshade, and sumac along with the control rations were fed to the birds ad-libitum and in a mash form. Table X illustrates the amounts of ingredients used in the different rations.

TABLE X

AMOUNT OF INGREDIENTS USED IN THE DIFFERENT RATIONS.
TO MAKE 50 POUND BATCHES

	GRAPE I&IA lbs.	ROSE II&IIA lbs.	NIGHT-SHADE III&IIIA lbs.	SUMAC IV&IVA lbs.	CONTROL MASH V lbs.	CONTROL GRAIN VA lbs.
Yellow corn	19.75	19.75	19.75	19.75	27.25	27.25
Wheat	10.00	10.00	10.00	10.00	20.00	20.00
Meat scrap	2.50	2.50	2.50	2.50	2.50	2.50
Salt	0.25	0.25	0.25	0.25	0.25	0.25
Grape	17.50					
Rose		17.50				
Nightshade			17.50			
Sumac				17.50		

Cereal grains, meat scrap, greens, and grit composed the control rations which were presented in both whole and mash form. The test diets were also presented in mash form for by this method of presentation there was no opportunity for the birds to select grains or fruits at random and it allows for the consuming of the test rations in the desired ratio.

Table XI gives the composition, in percentage, of the control diests and the basal plus the test foods that are to be evaluated.

TABLE XI

PERCENTAGE COMPOSITION OF CONTROL, BASAL, AND TEST DIET

CONTROL FOODS	BASAL AND TEST FOODS
Corn.......54.50%	Corn.......34.50%
Wheat......40.00%	Wheat......25.00%
Meat scrap. 5.00%	Meat scrap. 5.00%
Greens..... 3.00%	Greens..... 3.00%
Salt....... 0.50%	Salt....... 0.50%
	**Test food..35.00%
103.00	103.00

To base a food study on a standard that will allow for a comparative evaluation, the diet must be one that will supply the necessary nutrients to keep the birds at an energy-equilibrium; i.e., to prevent any loss from its tissues. In other words, the basis for a comparative study may be designated as the "standard weight"[1] as the base-line for studying the influence of variable factors. Strictly speaking the "standard weight" may be considered as a combination of "maintenance"[2] and "growth"[3] and at a nutritive level that will promote the necessary body functions.

Quantities of food ingested will give some indication, on a comparative basis, of the nutritive value of the food. In the following Table XII the average amount of food consumed per/bird for the 11 weeks is tabulated.

TABLE XII

TOTAL AVERAGE FOOD CONSUMPTION PER/BIRD FOR THE PERIOD OF 11 WEEKS

DIET	AMOUNT CONSUMED (ounces)	AMOUNT CONSUMED (grams)
Control grain	139.51	3913.26
Nightshade	139.65	3917.18
Control mash	142.60	3999.93
Grape	160.47	4501.18
Rose-hip	165.79	4650.41
Sumac	180.67	5067.79

1 "Standard weight" an arbitrary term to denote a base-line from which to judge weight variations during the test period.

2 "Maintenance" the minimum amount of the various foods required to sustain the essential body processes at an optimum rate without gain or loss in body weight or change in body composition, exclusive of the food used in growth or expended in work or other productive functions.

3 "Growth" the nutrients required for the process that involves an increase in the structural tissues such as muscle and bone and also in the organs. Fat deposition is not growth. True growth is characterized primarily by an increase in protein, mineral matter and water. From the nutritional standpoint, growth involves a large intale of energy-producing foods to support growth processes.

Table XIII illustrates the comparative differences in the total amount of foods consumed over a period of 11 weeks by the average bird on the six (6) different diets. There is a pronounced difference in total food consumed but the explanation of this is best discussed after the weight reactions have been analyzed.

When the total food consumption is broken down to average weekly consumption, we have a fluctuation that is best illustrated in the following Figure 3 with the accompanying temperature Figure 3A.

Over the period of 11 weeks, the birds exhibit a decided variation in the total amount of food consumed. Figure 3 indicates the weekly variations in food consumption of the average bird when all diets are thrown together. There is a decided irregularity in average amount consumed during the first three weeks of the test and then a gradual flattening out after the 5th. week, but this should not be further analyzed for within the six totals that make up the average weekly food consumption there is a great variation. To be of more significance, each week's amount of each test diet must be evaluated in the comparison of food consumption to weight reaction and this will be taken up in more detail in another section.

To show the different amounts of food consumed by the test birds, Table XIII presents the average weekly food consumption and Figure 3 illustrates the trends of the food intake.

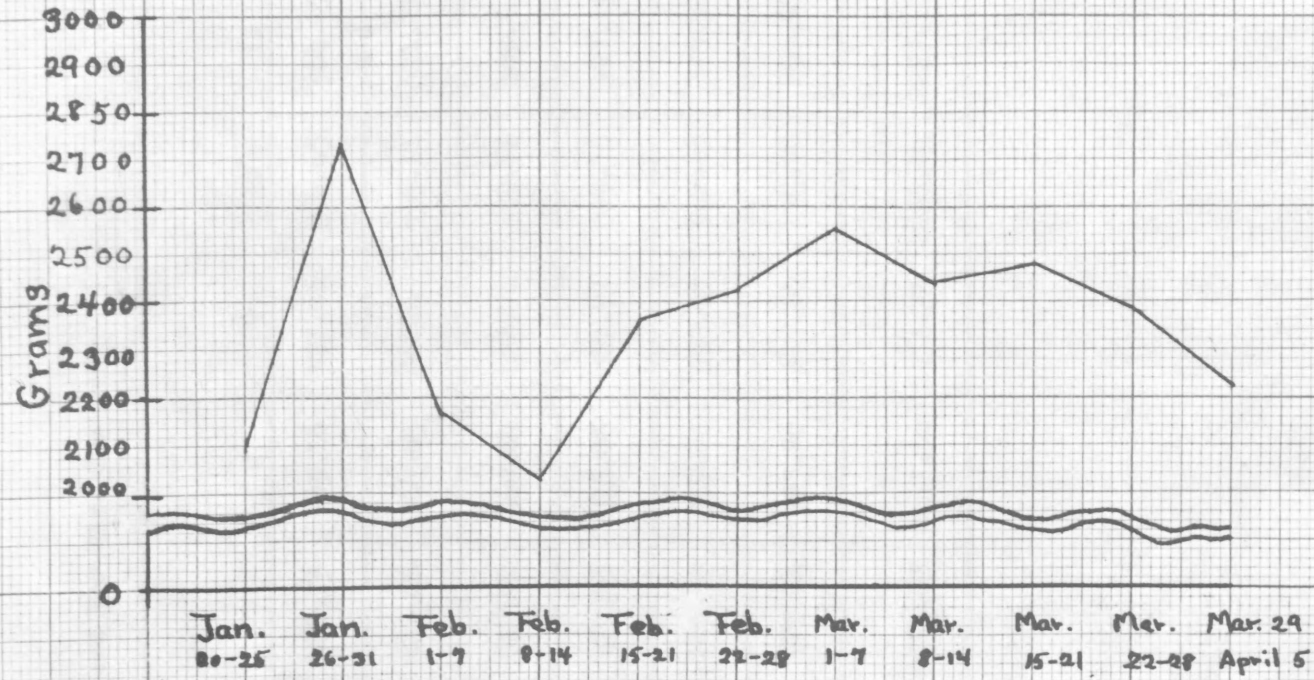

Figure 3. The Average Amount (Grams) Of Food Eaten Each Week By The Test And Control Birds.

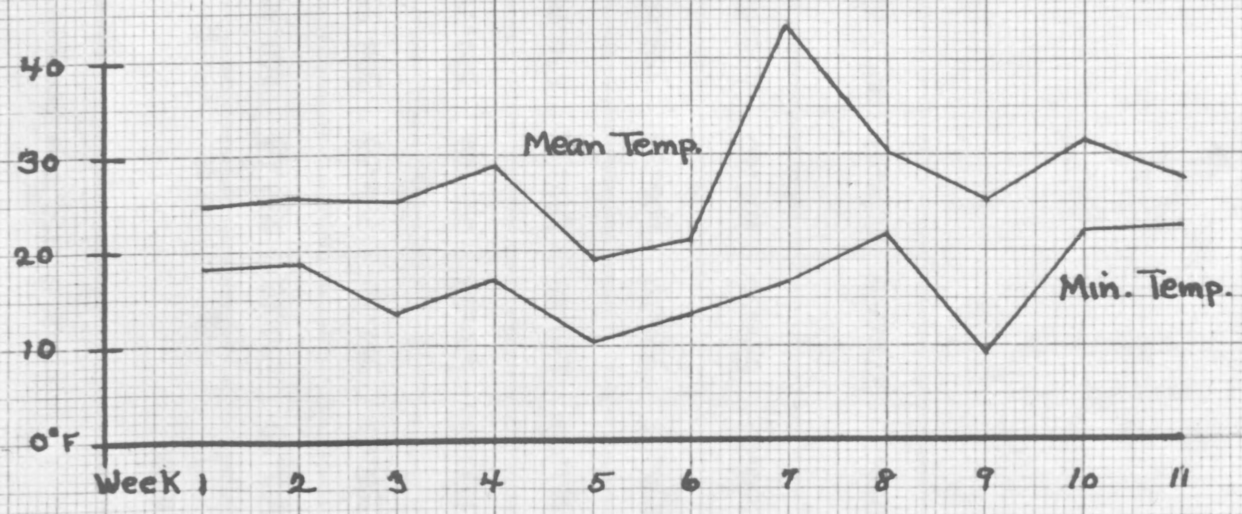

Figure 3A. The Minimum And Mean Temperature Ranges From January 20 To April 5, 1941.

TABLE XIII The Average Amount of Food Co[illegible]med Per Bird Per Week in Grams

DIET	WEEK 1	2	3	4	5	6	7	8	9	10	11
Control Grain	441.79	480.22	238.43	168.30	397.19	341.09	406.73	383.16	327.06	364.65	364.65
Control Mash	336.60	381.48	294.53	308.55	350.63	490.88	345.86	364.65	360.44	355.11	411.21
Grape	383.16	476.85	299.01	310.79	376.15	369.14	518.92	469.84	427.76	399.71	469.84
Rose-hip	341.08	439.26	481.34	430.00	427.76	413.74	472.08	476.85	387.93	383.16	397.19
Nightshade	256.93	397.19	406.73	359.88	394.94	383.16	283.30	359.88	350.63	350.63	373.91
Sumac	336.60	539.96	448.80	455.81	399.71	424.12	525.94	393.26	617.66	434.78	490.88
TOTALS	2096.2	2714.96	2168.83	2033.34	2346.38	2422.12	2552.83	2447.36	2471.77	2288.04	2227.17

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It may be stated that the amount of food consumed is a rough estimate of the value contained therein but no generalization of comparative values will be made until more of the experimental results have been presented.

To show an even finer degree of level of food consumption the average weekly food intake of the total test birds can be broken down to the average food consumption per bird - again realizing that the wide variations exhibited by the six different tests are combined. As a level of measurement, Dalke's (1933) experimental determination of the average daily food consumption of the pheasant will be used as illustrated in Figure 4.*

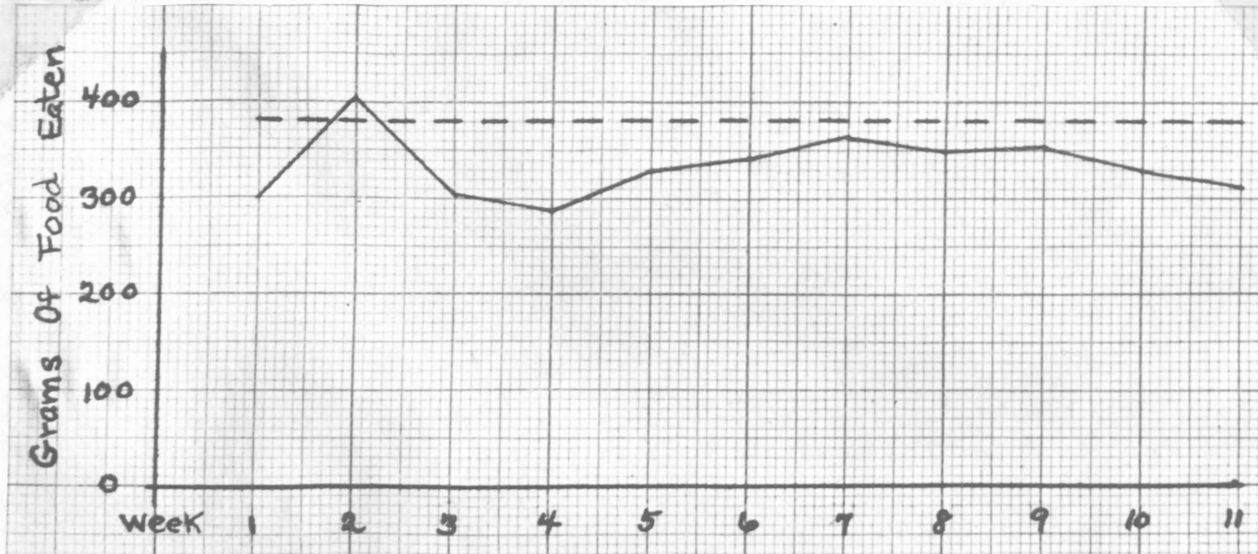

Figure 4. The solid line indicates the average weekly food consumption per bird. The broken line represents the theoretical amount of food that a bird will normally eat in a week during the winter.

* Taken from Dalke's thesis where he found that over a period of two months, birds fed on a complete diet averaged about 55 grams per day or 13.58 ounces per week.

The general weekly food consumption falls slightly below the level that Dalke (1933) gives, but there are numerous influences that cause this.

As the levels of food consumption indicate, the feeding trial becomes a record of the reaction of the bird to, of the function of a given ration.

In the type of experimental work made in this test series, in which the basal ration is constant and the individual test food supplemented, the results obtained are limited and tell us nothing as to why one diet proved better than another, unless the poorer one was so inadequate as a sounce of nutriment that it was little consumed or that it was consumed in large quantities without yielding the proper nutrients. To make a determination of the specific nutritive qualities of each of the fruits would be extremely involved and could not be undertaken in this limited study.

The basis for the comparative evaluation of the individual fruit is derived from the premise that a basal ration supplemented with the test fruits will yield an answer as to the comparative over-all effect of the fruits in the diet but tells nothing as to why one was better than the other unless the gross chemical analysis can supply this information.

Just as simple body-weight differences do not always tell the true story of the nutritive value of a food, so total food consumption alone, also fails to complete the true evaluation of a diet. To utilize the weight reaction and food consumption data, a composite relationship of food consumption to weight reaction may come closer to the actual values of the different foods. Food consumption efficiency as measured by grams of food required to produce one gram of gain, at the end of the 11 weeks is shown in Table XIV.

TABLE XIV

FOOD CONSUMPTION EFFICIENCY: GRAMS OF FOOD REQUIRED TO PRODUCE ONE GRAM OF GAIN PER BIRD

DIET(35-65)	TOTAL FOOD CONSUMPTION IN GRAMS/ BIRD	TOTAL GAIN* PER BIRD AT END OF 11 WEEKS	GRAMS OF FOOD REQUIRED TO MAKE ONE GRAM GAIN	RATING OF FOOD
1. Grape	4549.320	154.00	29.541	1
2. Nightshade	3959.078	61.00	64.902	2
3. Rose-hip	4700.250	49.40	95.144	3
4. Sumac	5121.995	49.50	103.488	4
5. Control grain	3955.108	34.00	116.326	5
6. Control mash	4042.710	-32.00	loss	6

As shown in the "rating" column of Table XIV, the relative values of the different test fruits are obvious. Diet (1) grape, showed the best efficiency, requiring 29.541 grams of food to produce 1 gram of gain.

* Final weight gains were figured from the final 11th. week's trial period. Weekly weights fluctuated, so the figures given are approximations, all made at the same time.

Series (2), nightshade, followed the grape-diet in efficiency and required 64.902 grams of food to make 1 gram of gain.

Series (3), rose-hip, required 95.144 grams of food to make 1 gram of weight gain.

Series (4), sumac, was the least efficient of the test foods and required a total of 103.488 grams of food to make 1 gram gain in live weight.

The control diets, series (5) and (6), appear to be below the level of any of the test foods in efficiency to make weight gains. Series (5), whole grain, required 116.326 grams of food to make 1 gram of gain, while Series (6), mash-grain, resulted in a loss of 32 grams of weight.

Percentage gain results from the control and test diets correspond with the efficiency-ratings and help to establish the comparative nutritive values of the four test fruits.

COMPARATIVE FOOD ANALYSIS--CHEMICAL COMPOSITION: The chemical analysis of a food or of a feed-ration to determine its complete nutritive value as a food is necessarily limited, for the chemical composition of foods does not indicate the available and essential amino acids, mineral elements, vitamins nor does it show to what extent these nutrients are utilized in the bird's body. To be accurate and to make a complete determination of the nutritive value of a ration, the following data must be considered:

1. the total nutrient content of the food.
2. the loss or wastage of various nutrients occurring

in digestion.

3. the loss or wastage of nutrients that occurs in the process of conversion of such into body tissue constituents.

Wild fruits show a wide diversity in nutritional character, some being highly concentrated foods capable of furnishing a large part of the bird's diet, while other foods contain little nutriment and serve only as minor components of a highly complex diet. To measure this potential nutritive difference of the wild fruits, it appears quite sound that comparative-nutritive values may be determined by this method of adding the test supplements to a basic ration. Fruits added to the basal ration should, over a period of time, permit satisfactory comparison of relative-nutritive value.

To supplement growth, health, and fertility results as derived from a feeding trial, the data derived from a chemical analysis of the food and feeds will serve as a partial indicator of the contained nutritive value. Therefore, it will be appropriate to state the chemical composition of the individual foods and of the composite rations and also to compare the differences in chemical value of the various experimental foods plus the control rations. For a comparison, Table XV will indicate the approximate chemical composition of pheasant diets derived from the natural feeding habits of the birds in the wild; taken from Rhode Island * and Michigan ** studies.

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* Wright, T. Fall food of the pheasant and bob-white in Washington County, Rhode Island.

** Dalke, P. D. Doctoral Thesis, University of Michigan.

TABLE XV

APPROXIMATE CHEMICAL COMPOSITION OF NATURAL PHEASANT DIETS. FALL AND WINTER STUDIES.

LOCATION	DIET	PROTEIN	FAT	CARBOHYDRATES CRUDE FIBER	CARBOHYDRATES N.F.EXT.	ASH	MOIST
Fall - R.I.	natural	12.90	15.78	17.48	44.97=62.45	2.09	6.78
Fall - Mich.	"	15.00	6.68	total carbohydrates 71.50		4.17	11.83
Winter-Mich.	"	12.00	5.40	" " 68.75		3.25	17.62

There is a decided difference in the nutritional make-up of th the Rhode Island and the Michigan fall foods but this is to be expected because of the diversity of the natural foods available in each region.

Considering Dalke's analysis of the winter food, it is seen that the control and test-diets of the experimental birds are fairly similar in composition. One interesting fact is the nearly similar quantities of carbohydrates in all of the natural diets.

Chemical composition of the foods and test rations: Further evaluation of the comparative values of the different rations on a chemical basis shows, in Table XVI, the approximate composite analysis of the food items making up the basal and test-fruits.

The analysis in Table XVI indicates in a rough manner the approximate nutritive level of the various foods.

An interesting fact is the similarity of chemical com-

TABLE XVI

THE APPROXIMATE CHEMICAL COMPOSITION OF THE FOOD ITEMS MAKING UP THE CONTROL AND TEST DIETS*

DIET(35-65)	PROTEIN	FAT	CARBOHYDRATES CRUDE FIBER	N.F.EXT.	ASH	MOISTURE
Control	12.750	3.568	2.143	67.805	2.607	14.318
Grape (1)	12.209	5.505	8.554	59.941	3.403	12.954
Nightshade (2)	13.924	6.824	8.761	55.587	3.536	13.833
Rose-hip (3)	12.363	4.444	9.041	61.117	3.410	12.135
Sumac (4)	10.774	8.140	10.931	57.603	2.986	10.055

position of the natural pheasant diet in winter and the grape diet that rated as the most efficient of the trial fruits.

To present the differences in the chemical values of the control diets, the test fruit-diets, and the natural wild-diets, Figure 5 and 5A indicates the comparative amounts of nutrients in each diet.

As indicated in Figure 5 and 5A, the various nutrients do not differ greatly in quantity but it is the quality factor that must be considered in evaluating nutritive differences. Most of the nutritional value of a food lies in the protein quality and in the mineral and vitamin portions of the foods. As this study does not include the biochemical analysis of the foods, only the gross-nutrient qualities may be evaluated. The basal grains are known to be of a fairly high nutritive character

* Individual wild fruits analyzed on an air dry basis by The Bureau of Animal Industries. The values for the basal grains and greens were taken from Jull, "Poultry Husbandry".

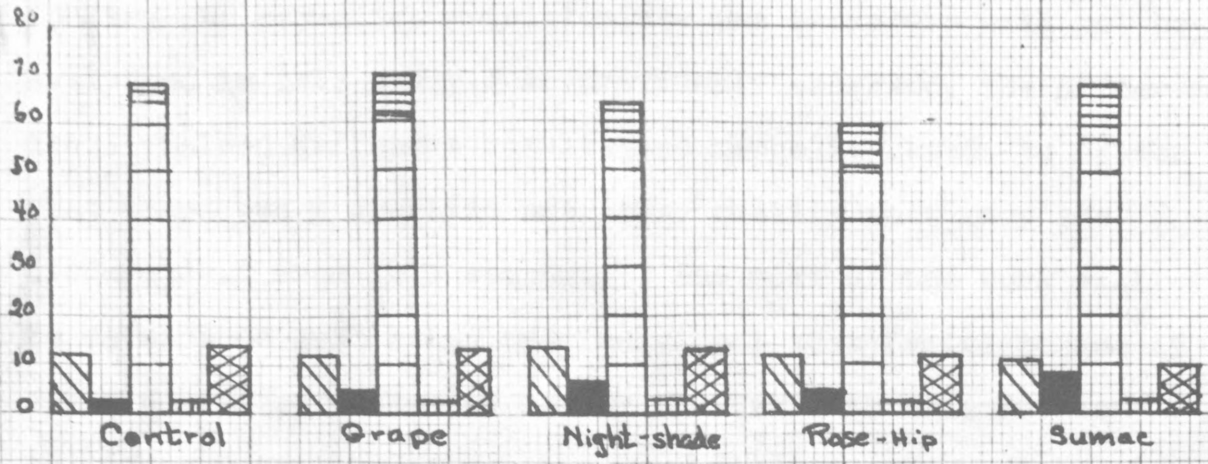

Figure 5. The comparative chemical composition of the control and test (35-65) diets

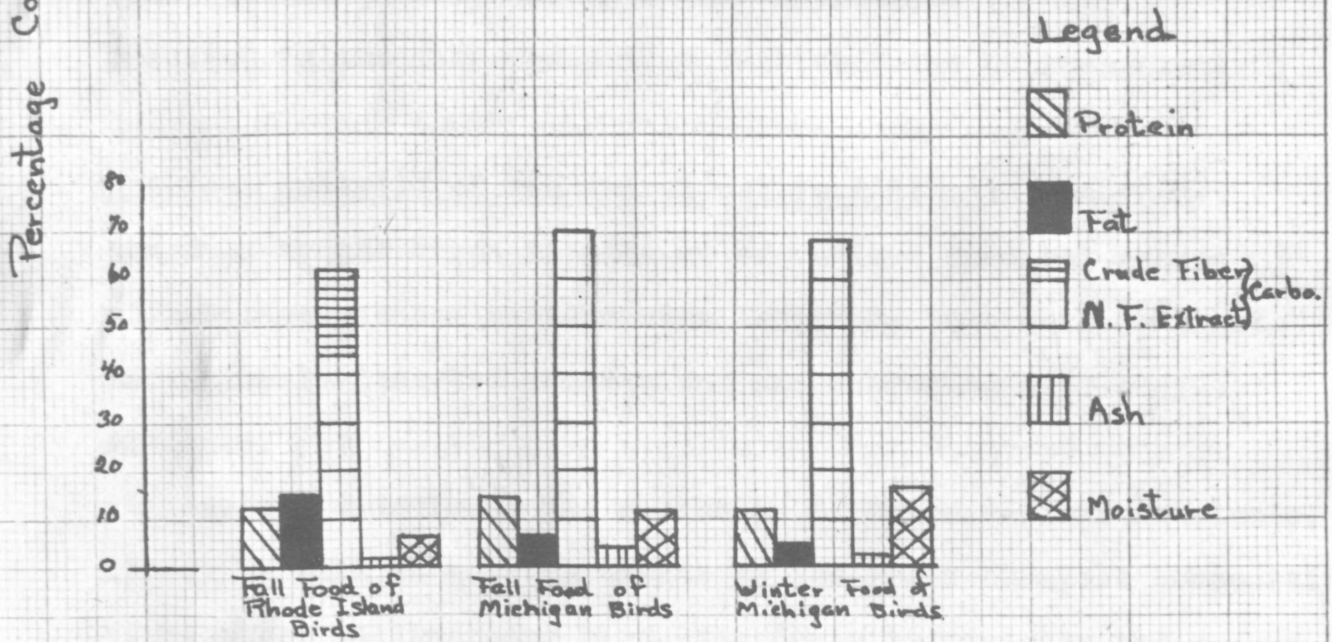

Figure 5A. The comparative chemical composition of foods eaten by wild pheasants in Rhode Island (Wright 57) and Michigan (Dalke 10).

and their various qualities have already been worked out by poultry and mammalian nutritionists and therefore will not be evaluated in this study. As previously observed, the different diets yielded different results and hence it stands to reason that there was a specific nutritive quality that made the difference. From this statement, the rest of the work will be devoted to evaluating the individual test fruits to see if any clue can be gotten as to why one fruit is of a greater or lesser nutritive value than another. As the basic ration was similar in all the test feedings, it is assumed that the nutrients in the basal ration were approximately similar in quantity and quality but that the supplements (fruits) resulted in the difference in nutritive value of each diet.

Chemical analysis of the individual food items: The food consumed by the birds is made up of various chemical groups of substances known as nutrients, which by intricate chemical and physiological transformations are converted into body elements.

Before describing the character of these various nutrients, it may be well to make reference to the gross chemical composition of a mature Gallinaceous bird, the domestic hen. In the following Table XVII, the average chemical composition of the entire bird's body is given.*

The data in Table XVII does not reveal the small amount of carbohydrate which is present in the body. Carbohydrates

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* Jull, M. A. Poultry Husbandry.

TABLE XVII

GROSS CHEMICAL COMPOSITION OF A HEN'S BODY

SPECIES	PROTEIN	FAT	MINERAL MATTER	WATER
Domestic hen	21.00	19.00	3.20	56.00

occur as much less than 1 % in the body at any given time and are constantly formed and broken down.

The chemical elements which make up the bird's body are not evenly distributed throughout the various organs but are more or less localized according to their functions. Water is an essential constituent of every part of the body and varies greatly in distribution. Proteins are present in every cell, and other than water are the principal constituents of the organs and soft structures of the body, such as muscles, tendons, and connective tissue.

The fat is localized in the adipose tissue which occurs under the skin, around the intestines, the kidneys, and other organs as well as in small amounts throughout every cell of the body.

The small amounts of carbohydrates in the body is found principally in the liver, the blood, and the muscles. Minerals are found largely in the skeletal structure as well as throughout the body in combination with other nutrients.

Before analysing the nutrient values of the test fruits, it would be appropriate to explain in more detail the elementary composition of the nutrients and their role in metabolism;

Proteins: this term is a collective one which embraces an enormous group of closely related but physiologically different members. Plant and animal proteins differ from each other as do the proteins in the various organs, tissues, and fluids of the body.

Proteins are classified into three groups, primarily on a physical basis-the simple, the conjugate, and the derived proteins. The essential difference of the various types is determined by the kinds and amounts of amino-acids present.

The biological value of the proteins is determined by the number of amino-acids present, the larger the number of amino-acids, the smaller the intake of food protein need be.

The difference between crude and digestible protein is in the kinds and amounts of amino-acids present and should be a biological rather than a chemical difference, so no differentiation will be made of protein types.

In general, the proteins provide for tissue repair and growth. They cannot be stored in the body and the supply in an animal's body is normally not enough to last 24 hours. It cannot be transformed and is less digestible than carbohydrates.

Fats: The fats contain a group of substances insoluble in water but soluble in ether, chloform, and benzene. There are two types of fats in the animal body, the "constant element" and the "variable element". The "variable element" is the fat that is drawn upon from the fat tissues to furnish energy for body processes during periods of inadequate food intake; the "constant element" remains intact as a constituent of functioning cells.

Fat serves not only as a source of energy in the body but also as an insulating layer to retain body heat. Fats have a caloric value twice that of carbohydrates or the proteins and are the main source of stored energy easily convertible to sugars.

Carbohydrates: This group of nutrients includes the sugars, starches, cellulose, and gums and are heat and energy producers. Carbohydrates form the largest part of an animal's diet but occur only as a small constituent of the animal body.

The carbohydrates are determined chemically as crude fiber and nitrogen-free extract. The crude fiber consists primarily of cellulose and other sugars which serve as the structural and protective parts of plants. The nitrogen-free extract comprises the sugar, starches, and a large part of material classed as hemicellulose and is the most easily digested.

Crude fiber digestion differs for the given species of animal and also with the difference in physical and chemical nature of the food. IN birds, crude fiber is poorly digested but valuable in supplying bulk to the diet. In general, the carbohydrates are the main source of energy and heat. They are convertible to fat and can be stored in this form; they are easily digested and help in the metabolism of other foods.

Ash: Ash is the residue left after the organic matter is burned and is composed of the various mineral elements. The minerals serve the body in many ways and give rigidity and strength to the skeletal structures as well as being important in the diet. Minerals are ingested as constituents of organic compounds and as grit.

Water: Water comprises a large protion of the animal's body and most tissues contain from 70-90% of this substance. Water is the ideal dispersing medium and functions in connection with the transportation of metabolic products, with secretion, and excretion and many other bodily processes.

Vitamins: Vitamins are complex organic compounds consisting of various combinations and proportions of carbon, hydrogen, oxygen, nitrogen, and other elements that are dietary essentials. At the present, seven vitamins are known while others are still being investigated.

Species differ markedly as to the essential vitamins needed. No single food contains all the necessary vitamins, hence a varied diet is required to supply the essential ones. Briefly, vitamins are essential for growth, for appetite, to build resistance to disease, to aid in mineral assimilation, for healthy reproduction, and numerous other physiological precesses.

Chemical analysis of the test fruits: With the elementary description of the different nutrients and their chemical composition and values stated, a more detailed study will be made of the chemical composition of the individual food items used in the feeding test. Table XVIII shows the chemical composition of these.

TABLE XVIII

CHEMICAL ANALYSIS OF THE INDIVIDUAL FOOD ITEMS MAKING UP CONTROL, AND TEST DIETS

FOOD	CRUDE PROTEIN	DIGEST. PROTEIN	FAT	CRUDE FIBER	N.F.EXT.	TOTAL CARBO.	ASH	MOISTURE
Corn	9.30	---	4.3	1.9	70.30	72.2	1.30	12.90
Wheat	12.30	9.80	1.80	2.40	71.10	73.50	1.80	10.60
Meat scrap	53.90	50.10	9.90	2.20	5.00	7.20	21.10	7.10
Salt								
Greens	2.20	---	0.30	0.90	4.70	5.60	0.80	91.10
Grape	9.04	7.84	8.77	20.46	50.06	70.52	4.07	7.90
Night-shade	13.94	---	12.53	21.05	37.62	58.67	4.45	10.41
Rosehip	9.48	8.96	5.73	21.85	53.42	75.27	4.09	5.56
Sumac	4.94	4.64	16.29	27.25	43.38	70.63	2.88	5.33

As indicated in Table XVIII the basal foods, corn, wheat, meat scrap, salt and greens differ greatly from the chemical composition of the wild fruits. The nutritive values of the combined cereal grains as pheasant feed is well known, but when corn or wheat are considered as individual feeds, or as combinations there is much to be desired as a well balanced ration.[1] Corn and wheat when not supplemented by other foods result in nervousness, retardation of growth, and impaired reproductive

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1 Analysis of cereal grains, meat-scrap, and cabbage from Jull, M. A. Poultry Husbandry, "Feeding Practice". Pp. 285.

ability.[1] Wight (1941) stated that references to British pheasant literature indicate that excessively high corn diets may be fatal to pheasants. However, as this study did not make a comparative evaluation of the cereal grains, only general comment will be made as to the basal ration or the control ration other than that given in Table XVIII.

Corn, when supplemented by other foods, is an excellent winter staple food for pheasants. Yellow corn yields upon analysis approximately 9.3% protein, 4.3% fat, 1.9% crude-fiber, and 69.4% nitrogen-free extract. The ash yield is 1.3% and the moisture content is approximately 12.9%.

Wheat is somewhat similar to corn in chemical composition but has a protein content of 12.3% of which 9.8% is digestible, the fat content is 1.8%, the carbohydrates yield 2.4% crude-fiber, and 71.1% nitrogen-free extract. The mineral content is approximately 1.8% and the moisture content is 10.6%.

The nutritive evaluation, by chemical methods, of corn and wheat indicate that they are good foods for fattening and energy production, but poor in supplying the nutritional needs for reproduction. (See appendix, figure 5 and Table I).

Meat scrap, salt, and greens are the supplements, and furnish small amounts of essential nutrients to the bird's diet. The results of the chemical analysis of the test fruits are given again in Table XIX in order of their comparative nutritional rating.

All results given in Table XIX are derived from fruits

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1 Dove, W. F. A study of the individuality in the nutritive instinct and the causes and effects of variation in the diet. American Nature. Vol. 69. Pp. 1935.

TABLE XIX

THE CHEMICAL ANALYSIS OF THE FRUITS USED TO*
DETERMINE THE COMPARATIVE NUTRITIVE VALUE

FRUIT	CRUDE PROTEIN	DIGESTIBLE PROTEIN	FAT	CARBOHYDRATES CRUDE FIBER	N.F.EXT.	TOTAL CARBO-HYDRATE	ASH	MOIS-TURE
Frost grape	9.04	7.84	8.77	20.46	50.06	70.52	4.07	7.90
Night-shade	13.94	----	12.53	21.05	37.62	58.67	4.45	10.41
Japanese rose	9.48	8.96	5.73	21.85	53.42	75.27	4.09	5.56
Sumac	4.94	4.64	16.29	27.25	43.38	70.63	2.88	5.33

that were exposed to normal winter conditions from December through February and then air-dried for two weeks at room temperature.

(The only method that can be used in the chemical analysis of food is the procedure of pulverizing the material to a fine mass; this pulverizing of the foods may result in the true determination of chemical value of the fruit but not the value that the bird derives because often the fruits are not ground in the gizzard to the extent to which they are in the chemical tests).**

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* Analysis on an air-dry basis by the U.S.D.A. Bureau of Animal Industry.

** A further discussion of the "grinding factor" will be made in the general discussion.

Grape , Vitis cordifolia, ranked first in comparative nutritive value. The crude protein of grape is 9.04% and the digestible-protein is 7.84%. The fat level is 8.77% while the carbohydrates yield 20.48% crude-fiber and 50.06% nitrogen-free extract. The determinable mineral content is 4.07%, and the moisture content is 7.80%, as seen in Table XIX. The analysis of the grape comes the closest to being high in all the desirable nutrients. The grape has a fairly high carbohydrate content and is therefore of value principally for maintenance purposes. As with the other fruits to be evaluated, the nutritional value of the grape depends largely upon the pheasant's ability to utilize the fruit and seed. Swenk (6) finds that 80% of the seeds are crushed when grape is fed as a single item of diet.

Nightshade, Solanum dulcamara, ranks second in the comparative value in this study. The crude protein is 13.94% (the digestible protein not determined). The fat content is 12.53% while the carbohydrates yield 21.05% crude fiber and 37.62% nitrogen-free extract to total a carbohydrate content of 58.67%. Ash content is approximately 4.45% and the moisture content is 10.41% for the room-dried fruit. Nightshade has a fairly high protein content that provides for tissue repair and growth and it also contains a fat content that is desirable for it serves as a source of energy that can be stored and also is easily converted to sugars. When nightshade is fed as a single food item of diet, Swank (6) finds that approximately 98% of the seeds are utilized (cracked).

Japanese rose, Rosa multiflora, ranked third in comparative nutritive value. The crude protein of the rose seed and berry is 9.48% and the digestible protein is 8.97%. Total carbohydrates value is approximately 75.27% with 21.85% as crude fiber and 53.42% as nitrogen-free extract. The ash content is 4.09% and the room-dried moisture content is 5.33%. The apparent nutritive value of the rose-hips as indicated by the chemical analysis shows that the digestible protein content is above the percentage of the other fruits and as such indicates that it is a type of food that must be constantly replenished if it is to be of winter value to a pheasant. The fat content is very low and consequently this fruit is a poor source of energy that can be stored in the body for any length of time. A total carbohydrate content of 75.27% with a 21.85% content of crude fiber and a 53.42% content of nitrogen-free extract; although high in crude fiber, the nitrogen-free extract level is a desirable one. Birds fed on rosehips alone, where found by Swank (6) to be able to utilize (crack) approximately 80% of the amount consumed.

Sumac, <u>Rhus glabra</u>, ranked fourth among the four test fruits in comparative nutritive value. Of a 4.94% protein content, 4.64% was digestible protein. A fat content of 16.29% for the sumac was the highest for all the test fruits. The total carbohydrate content was 70.63% with 27.25% as crude fiber and 43.38% as nitrogen-free extract. A very low ash content of 2.88% and a moisture content of 5.33%.

In general, sumac is a poor food in all the desired nutrients. The protein content is very low and as such it appears doubtful if the pheasant could derive its required proteins from a sumac diet. The fat content is fairly high as compared to the fat contents of the other test foods; possibly, with such a fat content sumac may be better food than it is usually credited to be. The crude fiber content is relatively high and thus is not a good food in itself; the nitrogen-free extract is also fairly low and hence is a poor source of energy and heat in respect to the bird's normal requirement and the general inability of the bird to store this nutrient in the body for any length of time.

Sumac has a very hard seed and this factor may influence the complete food value of the fruit. Swank (6) states that pheasants fed only sumac fruits utilized (cracked) approximately 80% of what they consumed.

SUMMARY AND DISCUSSION OF RESULTS

SCOPE: In making this study, it was recognized that the possibilities of representing actual food values by chemical analysis of the individual food items or of the complete diet was inadequate to show the true nutritive value so a method was tried whereby a basic grain ration (65%) was used and the various wild fruits to be evaluated were then added as a supplement (35%). It was expected that the addition of the supplement (fruits) to a common basal(grain) ration would permit a satisfactory comparison of comparative nutritive value or differences.

Wild fruits are exceedingly diverse in nutritive character, some being concentrated foods and able to supply a large portion of the pheasant's requirements whereas other foods contain little nutritiment and normally serve as minor but essential components of highly complex diets. Leopold (1937) made a statement that adequately summarizes tha problem of food; "experience tells us little or nothing about why certain foods are eaten or rejected, or what role the various food plays in sustenance or reproduction of the species. Even the most scientific food habits research tells us what has been eaten, but never how much and never for what reason".[1] This quotation expresses the viewpoint of a number of persons interested in animal nutrition. In this limited study, an attempt was made to determine the comparative nutritive values of four

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[1] Leopold, Aldo. Control of food and water, Game Management. Pp. 253.

wild fruits that serve as pheasant food during late fall and winter months -- but still nothing definite can be said about "why such foods are taken". Included in the appendix (figure 5 and Table I) is a preliminary summary of the effect of wild fruits upon the potential breeding capacity of the birds fed a 65% supplement of this fruit for eleven weeks. The standard of comparison was to check against grain fed birds and a study of testis development was made.

METHODS: The experimental feeding was planned to duplicate winter conditions as closely as possible; foods available during all or part of the winter were used, for it was felt that these foods, available at a time when food conditions are at their worst, would best be evaluated first. During January, February, and March, the birds are undergoing physiological changes preparatory to the increased demands that will be made upon the body for reproductive purposes. It is not entirely with this reproductive phase but also with the general rigors of winter maintenance that the birds must cope with - these two factors, of winter maintenance and physiological change make the above mentioned months the ideal time to make such a food test.

To actually determine the complete nutritional value of a food would involve complicated biological and chemical assays that could not be attempted here. However, it is felt that the method described in this report may be an aid toward indicating the potential nutritive values of fruits. The complexity of the problem or practically any other problem that requires the use of living organisms is stated in the following words:

"the difficulty of working with biological entities with all the multiple facts involved are exceedingly great. The solution of problems comes slowly and they have to be approached from a viewpoint different from that of the mechanistic physiologist. It is true that conclusions drawn from the observation of organisms in their natural habitat are often shown to be incorrect or only partially correct when subjected to experimental tests. The reverse is equally true".[1]

Just as stated by Shelford (1934), the results derived from this experimental study must be considered and referred to as "experimental results"; how closely the findings can be applied in nature is still questionable use, but at least they are more than a guess.

The actual experimental method used in this study was a combination of several -- derived largely from poultry studies and from the few food studies made with pheasants. The experiment was carried out as a groupfeeding study, two duplicate pens of four birds each were used on each of the control and test diets. Birds to be used were chosen some time previous to the commencement of the experiment proper. All birds received the same treatment and were fed the same ration for a period of three weeks which was considered the "initiation period". During this period the birds were shifted about to make similar groups weight, temperament, etc. Male birds were used for it is generally considered that male birds utilize

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1 Shelford, V. E. Faith in the results of controlled laboratory experiments. Ecological Monograph. Vol. 4(4): 49.

their food better. To reduce the number of possible variables to a minimum, all experimental conditions that could possibly influence the results were controlled as much as possible; all birds were subjected in an equal degree to all experimental and environmental conditions except the one of food being studied.

The birds were fed "ad-libitum" for it was felt that this type of feeding more closely approximated natural feeding conditions than did a restricted diet and also, in a group feeding study there is no way to control the food intake of the individual.

Diets for the control and test birds were derived from a study of the wild pheasant's food (Dalke (1933), Wright (1941), Skoglund (1940), Severn (1936), Swenk (1930), and Fried (1940)); a basal grain ration was developped that was considered at a percentage level that would not mask the cumulative nutritional effect of fruits when added to the basal grains as a test supplement.

RESULTS: After a period of eleven (11) weeks of feeding the test diets, the experiment was terminated and the final results were derived from the following measurements:

1. Total average weight increase or decrease of groups.
2. Amount of food consumed to produce a unit gain in weight.
3. Chemical evaluation of complete diets and of individual test fruits.

In the results derived from such a group-feeding procedure, the greatest experimental error lies in the "average" for within a small group of seemingly like individuals there may be deviations that are great. However, in this study it was found that average deviations were not extreme and therefore the results of the "average" may bear some reliability for interpretation of results. Just as in gross chemical analysis, the gain in weight of a bird or the total amount of food per bird is not an entirely true measure of the nutritive value of the food or foods. Unequal gains induced by the consumption of the different test diets in equal amounts does not mean that these possess unequal value in any or all respects.. "for within certain limits an animal may increase or decrease a function by varying the quantity of food consumed or may partially submerge the qualitative deficiencies of the food by quantitative variations".[1] As indicated, no one measure of nutritive evaluation is valid in itself or even in combination. However, by the use of all three measurements, at least an empirical measurement of the comparative nutritive value of the four fruits under test may be made.

Another precaution that should be considered in the evaluation is the degree of digestibility of the various foods. The control diet contained feed stuffs that are fairly easily digested in their normal state whereas the test fruits were made up of fruits that in their normal state might be of very questionable digestibility. Hard seeds are not easily digestible by pheasants and often would not be ground up in a pheasant

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1 Dove, W. F. Individuality in Nutrition. American Naturalist. Vol. 69: 469.

gizzard but expelled in the feces. By cracking or grinding these seeds, as was done in all the experimental feedings, the digestibility may have been increased beyond all normal propobtions for the type of fruits used. Therefore the maximum values of the foods should have been determined.

Sumac, rose, and grape all have hard seed coats and in normal feeding these coats are ingested as solids and only partially ground to secure the inner kernels of rich food; nightshade has a much softer seed coat than either of the other seeds and from fecal examinations of wild birds it appears that this seed is fairly well briken up during digestion. The degree of digestibility of various hard-seeded fruits is almost entirely unknown but is greatly influenced by the general foods ingested by the bird. On restricted diets, it appears that there is a higher level of digestibility than is normally thought. Feeding studies made in 1940 by the writer found that pheasants when subjected to a diet entirely of a single food dagested that food to a greater extent than they did when the food in question was fed with a supplement.[1] Field studies of droppings that contained grape and sumac indicated that a certain amount of the fruit seeds were cracked but what proportion to the amount eaten is questionable. Further studies should be made on the degree

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Barske, P. Comparative nutritive values of wild fruits fed singly. Unpublished report. University of Connecticut. 1940.

of difestibility of seeds under varying conditions.[1]

With all the weaknesses of the experiment, the results appear to indicate some differences in food value of the various fruits and it was found that the scale of comparative nutritive value was as follows with corn as the level of measurement.

TABLE XX

COMPARATIVE NUTRITIVE VALUE OF THE TEST FRUITS

FRUIT	RATING
Grape	1
Nightshade	2
Rosehip	3
Sumac	4
Control grain	5
Control mash	6

These ratings were derived on the basis of total average gain and the amount of food required of each diet to make one gram

1 A preliminary report by Swank (6) on the ability of pheasants to utilize (crack) fruit seeds shows the following for birds fed single food items: nightshade 98%, sumac 88%, rose 80%, and grape 80%.

A continuation of Swank's study indicates that the above mentioned fruits, when fed with corn or mash show different degrees of being utilized.(cracked). Fruits fed in conjunction with mash, were utilized (cracked) to a greater extent than was fruit fed in conjunction with corn.

gain in body weight for the period of eleven (11) weeks. (Reference to the appendix shows the interesting results derived from a testes study of birds fed a high percentage of fruits in their diet.) In the above table XX, fruit diets surpass both of the control grain diets and as such may indicate not only the comparative nutritional differences of the fruits but also of the value of fruits in the winter diet of pheasants.

A final compaison of chemical analysis of the control and test diets indicates a fairly close similarity in gross chemical nutrient composition. The individual analysis of the test fruits indicates the variability in chemical composition and as such is another clue to the comparative nutritive value of the studied fruits. The similarity in gross chemical composition does not necessarily mean similarity in nutritive value for nutrients may be termed fats, proteins, and carbohydrates, but each one of these may be slightly different in chemical composition and hence have entirely different food values, also the nutrients of one food may not be valuable alone but in association with another nutriment of a different food, may result in an excellent ration.

How closely the results of the comparative nutritional values of the fruits may be translated to conditions in the wild is problematical for under natural wild conditions, the entire metabolic rate of the bird is much higher. In captivity there is a definite slowing up or lowering of the metabolic rate. Odum (19) states that "In general, these data indicate

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* Odum, E.P. Variations in the heartrate of birds: A study in physiological ecology. Ecological Monograph. Vol. 3(3): 318.

that domestic birds are physiologically inferior to comparable wild species".

The food of wild birds differs from the food of pen raised birds but possibly by a method of experimental testing, the relative nutritive values of foods eaten by wild birds may be evaluated beyond the "guess" stage.

CONCLUSIONS

1. Feeding trials are necessary to determine the true nutritional value of any particular food or diet.
2. The experimental evaluation of wild fruits by using a basal grain ration (65%) appears to be a progressive step toward a more accurate method of comparative nutritional evaluation of foods.
3. Evaluated on a comparative basis, using cereal grains as a control, the wild fruits were rated on a comparative nutritional basis as follows: (1) grape, (2) nightshade, (3) rosehip, (4) sumac.
4. As experimentally determined, the pheasants that were fed a percentage (35%) of wild fruits in their diets, appeared to be in the best physical condition.

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APPENDIX

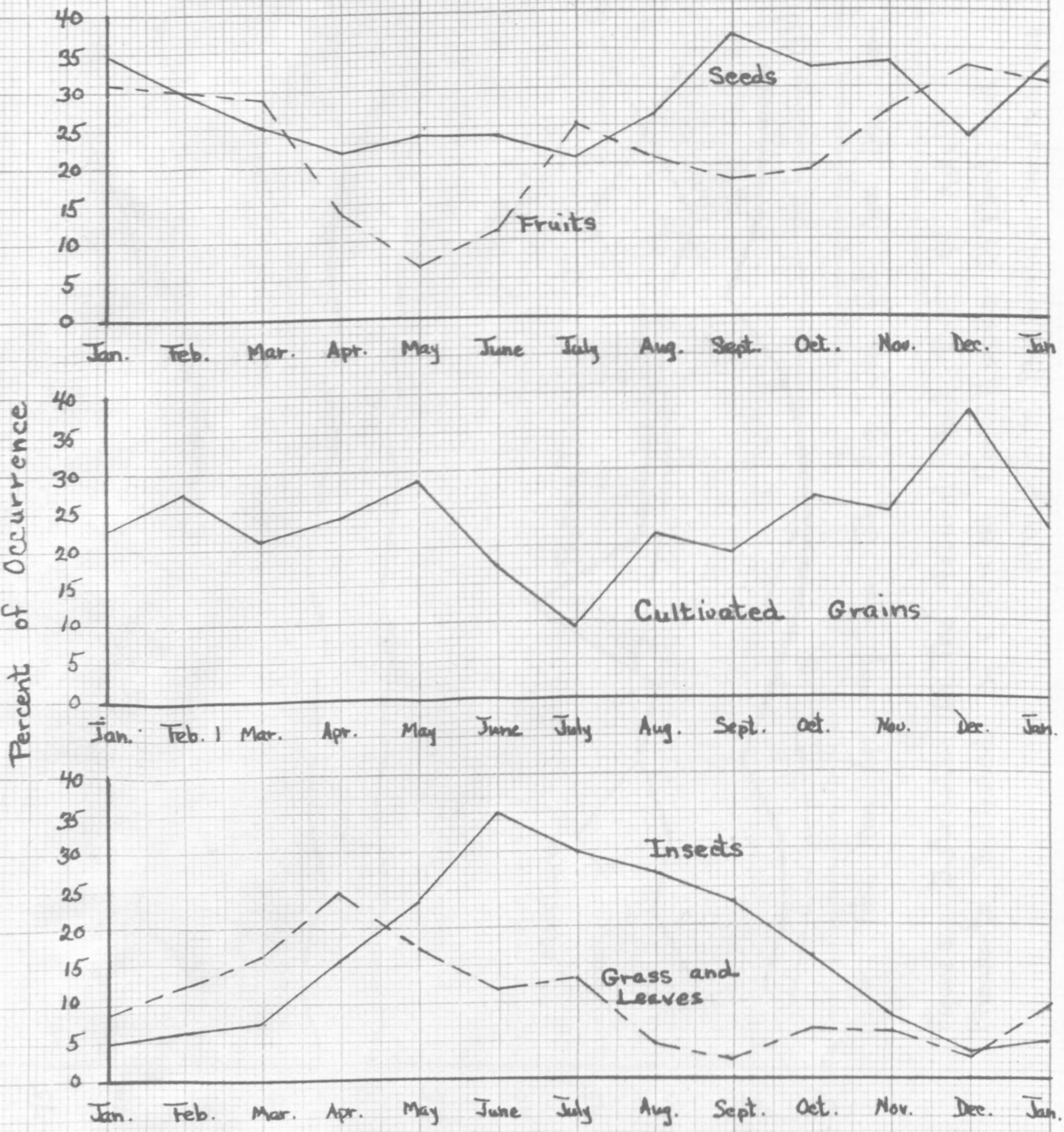

Figure 1. Frequency by months of the principal groups of pheasant foods occurring in ten thousand droppings. From P. Dalke Phd. Thesis University of Michigan, 1933

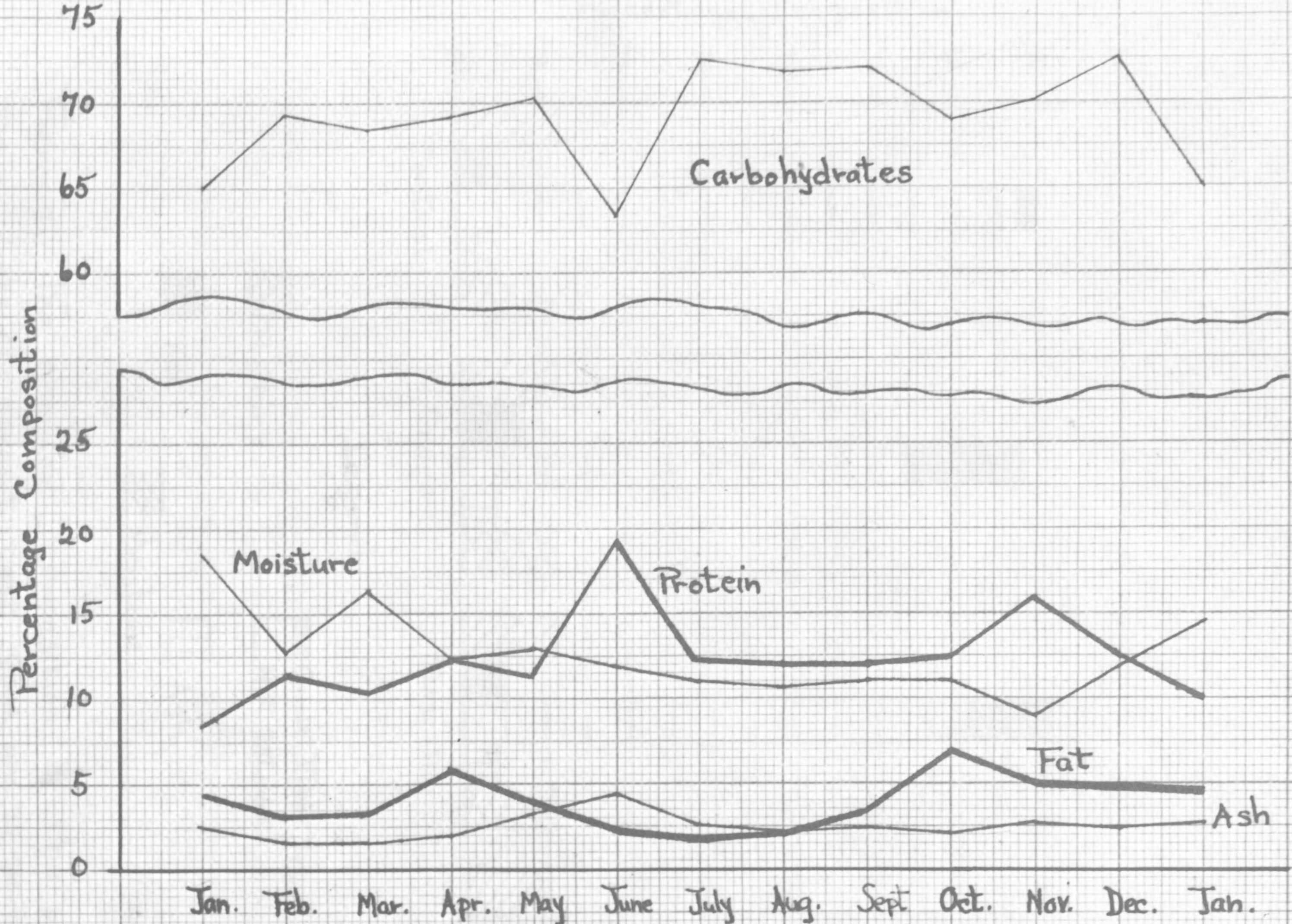

Figure 2. Distribution Of The Natural Plant Diet Of Adult Pheasants Indicated By Chemical Constituents Of Plant Diet.

After P. Dalke PhD. Dissertation Univ. of Mich. 1933

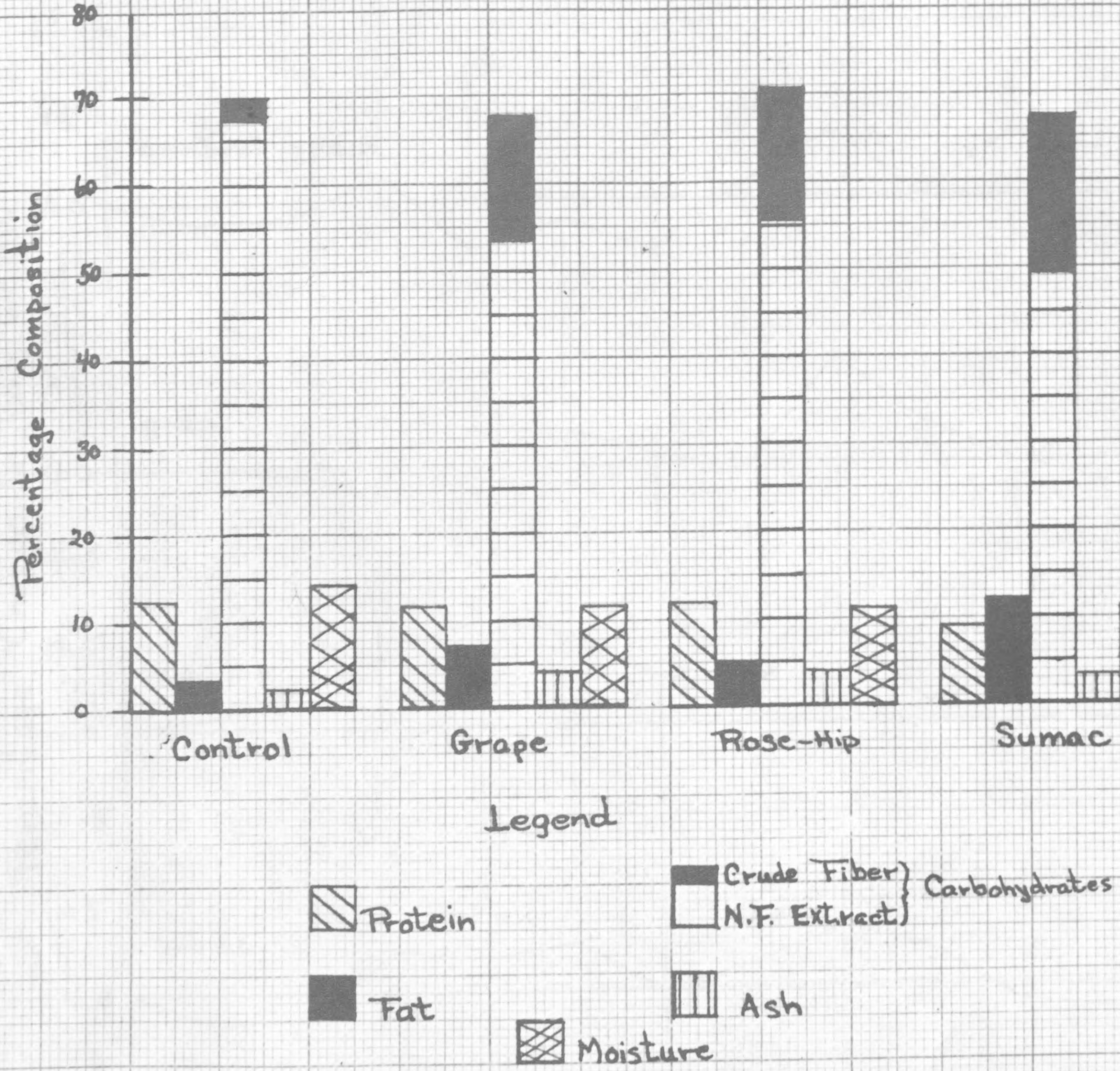

Figure 3. The chemical composition of the (65-35) Ratio diets (65 percent test food and 35 percent basal ration).

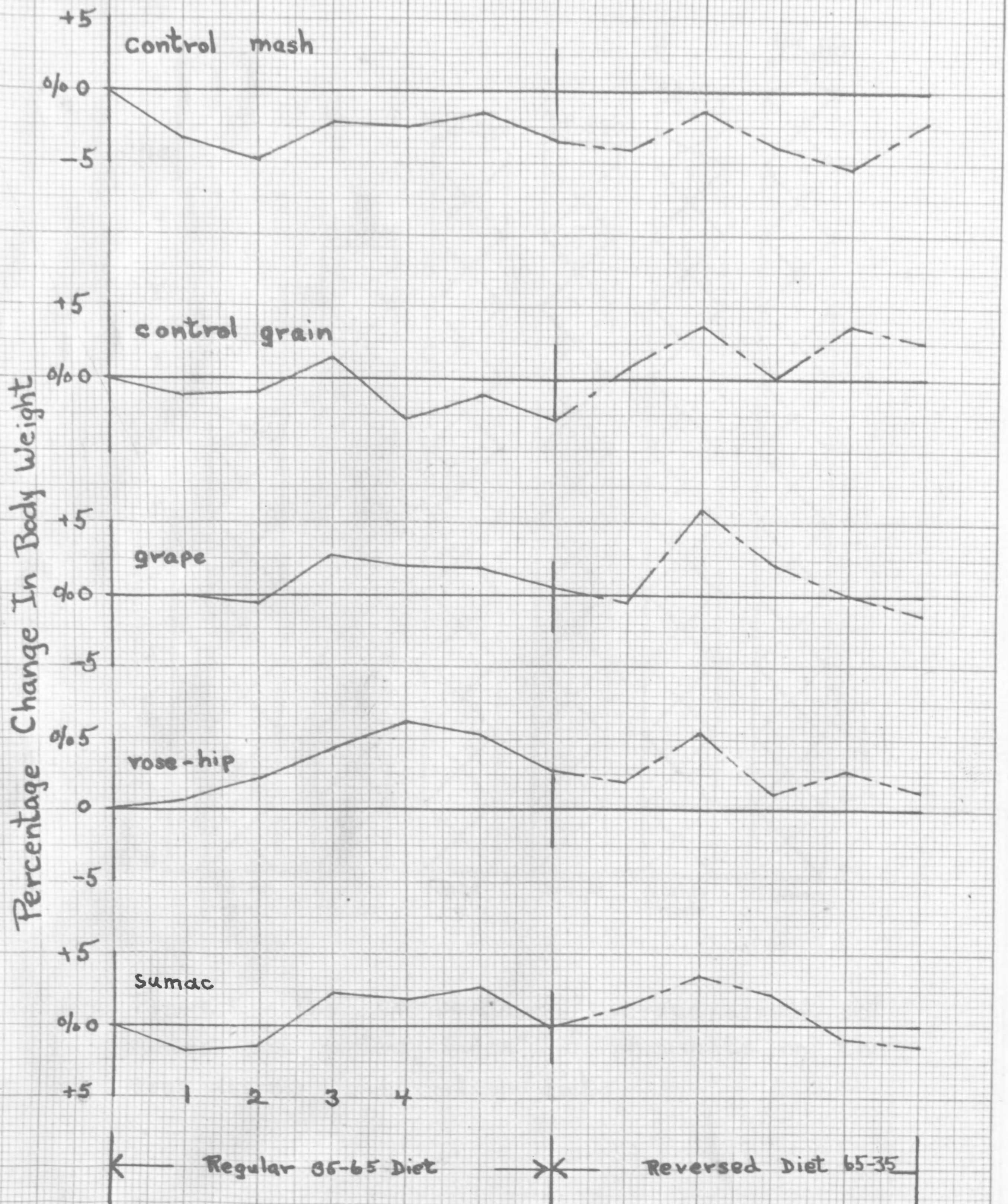

Figure 4. The weekly variations in average group weights of birds started after the sixth week on the 65-35 diet.

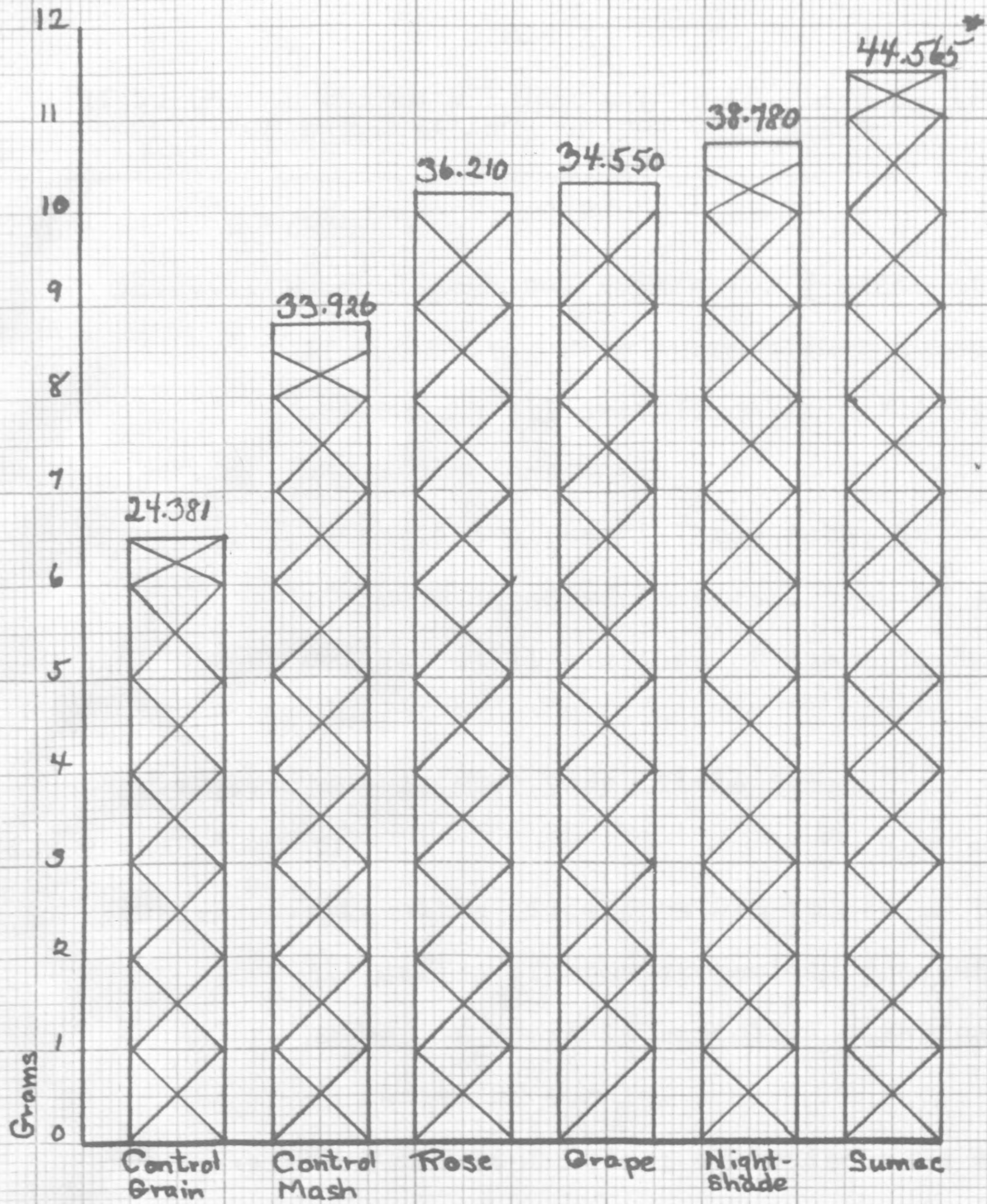

Figure 5. The comparative average weight of testes and testes index* of pheasants on the test (65-35) and control diets.

*The teste index is derived from the total volume of both testis as derived by Bissonette's formula $V = \frac{4}{3}\pi ab^2$.

TABLE I

HISTOLOGICAL TESTES DEVELOPMENT UP TO MARCH 4, 1941
OF THE PHEASANTS ON THE TEST DIETS

DIET - GRAIN CONTROL

#1........normal germinal epithelium ½ width of lumen of the tube. Free sperm within lumen. Numbers present in all sertoli cells. All stages of maturation present.

#2........Epithelium almost filling tube; large number of sperm embedded in distal tips of sertoli cells. Small clusters of sperm in lumen of tube.

#3........Same as #2. Very little lumen.

DIET - MASH CONTROL

#4........Epithelium fills from 2/3 to 3/4 of tubule. All stages of spermatogenisis present. Large number of sperm in sertoli. Some free sperm in center of tubule.

#5........No lumen to tubules; otherwise same as #4.

#6........Same as #5.

DIET - SUMAC (65:35)

#7........Epithelium fills 2/3 to 3/4 of tubule; otherwise same as #6.

#8........Same as #7.

DIET - NIGHTSHADE (35:65)

#9........Same as #8, epithelium occupies from 1/2 to 3/4 of lumen; large number of free sperm in center of tubules.

TABLE I (continued)

#10.......Same as #9; no lumen in tubules; large number of sperm in center of tubule.

#11.......Same as #10.

DIET - ROSEHIP (65:35)

#12.......Same as #11.

#13.......Same as #12.

#14.......Same as #13.

DIET - GRAPE (65:35)

#15.......Same as #14.

#16.......Smae as #15; large number of sperm.

Slides interpreted by Paul Ralph, Department of Zoology, University of Michigan, 1942.

TABLE II Organ Weights of One Year Old Male Pheasants (Grams)

Bird No.	Diet	Final Weight	Gizzard	Pancreas	Liver	Heart	Teste
39826	Sumac 65-35	1463 gr.	21.875 gr.	1.802 gr.	19.87 gr.	6.7 gr.	18.745 gr.
39821	65-35	1529	23.800	2.075	16.23	8.025	7.985
39811	C. Corn	1502	17.890	2.330	26.525	9.625	5.555
39828	C. Corn	1229	16.850	1.553	25.955	6.420	5.456
39827	C. Corn	1129	12.951		14.390	7.00	8.571
39805	C. Graw 65-35	1452	16.340	0.712	14.590	7.695	8.390
39803	65-35	1425	15.850	1.120	16.885	8.760	12.295
39808	Rose 65-35	1506	24.210	1.475	15.125	10.725	13.941
39805	65-35	1433	23.120	1.600	19.650	10.330	8.675
39809	65-35	1493	22.120		21.340	8.180	8.073
39823	N. Shade 35-65	1288	15.670	1.155	15.265	7.560	10.986
39824	35-65	1435	14.585	1.430	15.025	8.705	11.210
39810	35-65	1345	14.200	1.100	12.623	7.150	9.895

TABLE II (Continued)

Bird No.	Diet	Final Weight	Gizzard	Pancreas	Liver	Heart	Teste
39817	C. Mash	1421	17.085	1.445	21.460	12.680	7.954
39816	C. Mash	1339	14.460	1.555	22.860		9.287
39812	C. Mash	1428	16.705	1.700	18.140	7.753	9.160