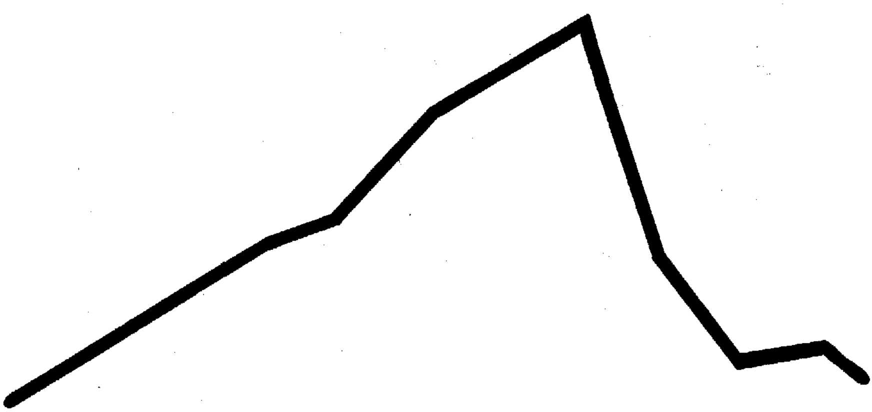
# SEASONAL VARIATION IN STRESS RESISTANCE AND SURVIVAL IN THE HEN PHEASANT



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# SEASONAL VARIATION IN STRESS RESISTANCE AND SURVIVAL IN THE HEN PHEASANT

By

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# INTRODUCTION

The size of Wisconsin's pheasant population is dependent primarily upon two things: the condition of the habitat and the pheasant's inherent capacity to survive the rigors of unfavorable environment. The state is currently effecting a program to improve and manage both the pheasant and its habitat. Habitat developed especially for wildlife, however, is costly. It is therefore of great importance, particularly in view of the variations in land use, to know specifically how much of a certain habitat type, e.g. for feeding, nesting, resting, or cover, is essential to sustaining or increasing wildlife crops.

At the same time it is necessary to collect additional information on the factors affecting the survival of the birds before specific habitat improvements required to produce more upland game birds can be properly evaluated.

Great variation in the capacity to survive the various stresses of the environment and to reproduce young have been observed between different game species and between birds of the same species. Field studies have revealed the occurrence of fluctuations in the size of populations even in the seemingly best types of habitat. Periodic fluctuations in ruffed grouse populations and the continental pheasant decline in the early 1940's bear witness to this phenomenon, which is true of many other upland game species.

What are the primary causes of mortality in upland game birds? Generally the factors causing mortality can be separated into two classes —those which result in large losses that occur within a relatively short time and those that cause small losses over extended periods and are re-occurring constantly (e.g. in the California quail, Emlen, 1940). In some cases certain factors which cause relatively high annual losses within short periods of time are easily ascertained. Heavy winter kills of pheasants, for example, have occurred in several midwestern states as a result of ice storms or blizzards (Miller, 1948; Kirsch, 1951; and others). In such instances, carcasses can frequently be recovered. In general, however, it is almost impossible to follow birds in the field closely enough to determine all of the factors which cause mortality and the extent of such fatalities, particularly where losses are frequent but the number of animals dying at any one time is small.

Investigations made during the past decade have shown that the survival of wild upland game birds from one winter to the next is much lower than was previously believed possible. In Wisconsin, for example, 83–90 per cent of the bobwhite quail disappear from January of one winter through December of the next (Kabat, unpublished data). One might deduce that this high loss occurs only because of inferior habitat conditions in Wisconsin for quail. However, Missouri, which has many more quail, milder winter conditions, and more winter food and cover shows a high annual mortality as indicated by hunting season age ratios (Leopold, 1945; Bennitt, 1951). Wisconsin studies have shown that in addition to a high winter loss there is a correspondingly great decrease in the breeding population in spring and summer (Kabat and Thompson, unpublished).

Annual loss rates are more difficult to determine for Wisconsin pheasants than for quail. However, sex, age and turnover data obtained by trapping birds during successive winters have shown that during the period from 1937 to 1951, from 49 to 81 per cent of the pheasants alive on the study area in one winter disappeared by the next (Leopold *et al.*, 1943; Buss, 1946; McCabe, 1949; Thompson, 1951). Even under the near ideal conditions of Pelee Island where predation is very light, weather is mild, food is abundant in winter, and hayfield mowing loss is all but nonexistent, about half of the hens died from one fall to the next (Stokes, 1954).

Studies of pheasant weight cycles indicate that weight changes might be used as a laboratory technique to evaluate certain potential mortality factors under controlled conditions.

Inherent weight cycles have been observed in adult pheasants that are characterized by very low weights in summer and peak weights in early spring (Kirkpatrick, 1944; Leopold *et al.*, 1943; McCabe, 1949; Kabat *et al.*, 1950). Kabat *et al.* (1950) further observed that the weight cycle was correlated, in part at least, with the post-nuptial molt and suggested that a delay in the onset of molt and the normal gain in weight following the spring and summer loss could lower the general resistance to all mortality factors. These authors theorized on the basis of these observations that prolonged breeding, characterized by the laying of many eggs and renesting, constituted an abnormal stress and thus detrimentally affected survival. These studies also suggested that weight and wing molt changes may be manifestations of the pheasant's general response to environmental stress.

While field studies have provided evidence for population changes and limited information on mortality and survival, it appears that the explanation for these changes can be best determined through a combination of field and laboratory techniques. Many specific questions need to be answered. When does mortality occur? What are the causes? All through the year the bird is experiencing different situations, changes in weather, reproductive cycle, molting, etc. Which of these factors or combination of factors are most serious from the standpoint of making the birds vulnerable to another stress which will cause death?

## SCOPE OF STUDY

The primary objective of the experiments reported here was to determine whether there were periods during the year when hen pheasants were physiologically weaker than others. The design of the study was based on the general adaptation concept developed by Selye (1949). It was reasoned that throughout the year the pheasant is subjected to a complex of natural stresses—seasonal changes in the external environment and changes in the physiology of the bird such as reproduction and molting. These stresses could conceivably cause marked seasonal fluctuations in the pheasant's ability to resist added environmental stresses, thus greatly lowering its survival, and precipitating marked and sudden decreases in populations.

In order to demonstrate the existence of any variation in stress resistance, we applied the artificial stresses of caging and starvation to groups of hen pheasants at different times of the year. Preliminary studies showed that survival time, body weight changes, and changes in body temperature could be used as a means for ascertaining variation in the resistance to applied stresses.

A second objective was to determine the effect of caging as a stress upon the birds in contrast to a combination of caging and starvation.

The third objective was to investigate the relation of conditions such as wing molt and age to the hen's ability to withstand applied stress.

Eleven studies were undertaken at intervals during the period from July 1950 to August 1951, during which groups of hen pheasants were subjected to the standardized artificial stress of caging and starvation. A summary of each stress study is presented in Table 1. This table provides a ready source of information concerning the date of each study, the source of test birds, the number of birds, and their condition at the beginning of each experiment.

## Table 1

### Summary of Stress Studies on Ring-Necked Pheasant Hens

| Date of Study | Length of Applied Stress Period (Days) | Source of Pheasants | No. Birds | Physiological State | Initial Weight Average (Gms.) |
|---|---|---|---|---|---|
| July 23, 1950 | 13 | Game-farm breeders (one-year-olds) | 46 | Spent breeders in early post-nuptial molt stages | 816 |
| Sept. 22, 1950 | 21 | Game-farm breeders | 21 | Post spent breeders (approx. 2 months after egg laying); advanced molt stages | 942 |
| Oct. 18, 1950 | 8 | Game-farm breeders | 16 of the above | Had been subjected to stress in Sept. study period; advanced molt stages | 830 |
| Oct. 9, 1950 | 22 | Game-farm breeders | 6 | Post spent breeders; advanced molt stages | 954 |
| Dec. 16, 1950 | 20 | Game-farm immatures | 16 | Wintering birds | 1,008 |
| | | Wild pheasants trapped in Dane Co. | 16 | Wintering birds | 1,001 |
| Jan. 10, 1951 | 23 | Game-farm immatures | 15 | Wintering birds | 1,090 |
| | | Wild pheasants trapped in Milwaukee Co. | 15 | Wintering birds | 877 |
| Feb. 15, 1951 | 23 | Game-farm breeders (two-year-olds) | 11 | Wintering birds | 1,047 |
| | | Game-farm immatures (early hatch) | 13 | Wintering birds | 1,000 |
| | | Game-farm immatures (late hatch) | 12 | Wintering birds | 898 |
| April 4, 1951 | 28 | Game-farm breeders | 12 | Just prior to second year of egg laying | 1,134 |
| May 3, 1951 | 21 | Game-farm breeders | 6 | Approximately 2 weeks after start of second year of egg laying | 1,078 |
| June 12, 1951 | 17 | Game-farm breeders | | | |
| | | (Early hatch) | 7 | During egg-laying period | 1,028 |
| | | (Late hatch) | 6 | During egg-laying period | 1,004 |
| July 19, 1951 | 14 | Game-farm breeders | 16 | Near end of egg-laying period | 900 |
| Aug. 28, 1951 | 14 | Game-farm breeders | 16 | Approximately one month following egg-laying period | 861 |

The methods used in selecting and applying the artificial stress will be described first. The results will be presented next in three parts: (1) seasonal response of game-farm-breeder pheasants to applied stress; (2) the relation of various conditions to stress response; and (3) the response to caging as a stress. A discussion of these results and their implications for the management of pheasants will be presented last.

## DESCRIPTION OF THE STRESS METHOD

### Selection of the Applied Stress

The birds were subjected to the stress of caging and starvation. We believed this stress could be standardized and controlled and would produce a measurable response.

We assumed that starvation, or at least varying degrees of food shortages, respresented one of the significant stresses which the pheasant, and other wildlife species, undergoes in the wild, so that the implications derived from these studies would not be the result of entirely artificial conditions.

### Source of Birds

The main source of birds was a group of one-year-old ring-necked pheasant hens which had been separated on July 23, 1950 from the breeding stock of the Experimental Game and Fur Farm, Poynette. Random samples were taken from this group and used for the studies. They were two years old during the second year in which the studies were made.

These birds had been hatched the previous spring, held through the winter in four-acre holding fields, and transferred to 12 x 12-foot breeding pens in March. The birds were penned at the rate of one cock to 5 or 6 hens. The hens began to lay eggs in April. Eggs were taken from the pens daily. Normally at the game farm, hens are used for egg production from early April to June 1–15, after which time they are released into the wild. Most of the birds are still laying steadily. These birds lay, on the average, about 30 eggs each at the game farm prior to their release. However, the group of birds selected for the stress studies continued to lay until mid-July, 1950, averaging about 50 eggs each. The term "spent breeder" has been applied to these birds which had at this time stopped or nearly stopped laying eggs. Examinations of the ovaries of wild pheasants have shown that they also frequently lay 30–50 eggs (Buss, Meyer and Kabat, 1951).

The group of spent breeders was transferred from the 12 x 12-foot breeding pens in June to large wire-covered runs (approximately 30 x 60 feet) that contained some natural cover where they were kept until the next egg-laying period. While in the runs the birds were given an ample supply of feed and a daily supply of fresh water. During most of the year, except from November to mid-February, the feed consisted largely of pellets (containing approximately 20 per cent protein, 48 per cent carbohydrate and 5 per cent fat). From November to mid-February the pheasants were fed a high caloric diet consisting of corn and wheat.

In a few cases wild birds and immature game-farm birds were used for certain phases of the studies. Data on these birds are shown in Table 1 and will be discussed later.

Separate groups of hens were used in each of the studies. This was done to eliminate complications arising from any effects of previous stresses. An effort was made to select birds for each experiment which were similar in size and condition. Weight differences within a group were therefore less than if a strictly random sample of birds had been selected. Other studies indicate that physiological condition and behavior are generally similar for all game-farm birds which are exposed to or exist in like environments.

However, the results of the study are presented as if the same group has been sampled continuously (for example, in terms of *increasing* or *decreasing* weight or survival from one period to the next).

## Caging and Starvation Procedure

Caging and starvation were standardized and applied in the same manner to all groups of pheasants. During the stress period, which varied from 13 to 28 days, the birds were placed in wooden cages with one-inch, wire-mesh doors. Two different sizes of cages were used. The larger, 69 inches long by 22 inches wide by 15 inches high, received six birds; the smaller, 49 x 22 x 15 inches, received three birds. When birds died during the study, the remaining birds were recombined for purposes of maintaining similar densities in the cages. Throughout the experiments the cages were in an unheated building which served primarily as shade in summer and as a windbreak in winter.

During the experiments the birds were not given any food, although they received fresh water daily and their litter was changed frequently. Their beaks were blunted at the start of each experiment and at intervals during the study to prevent them from injuring each other by picking.

On the first day of stress and at 7-day intervals during the study, determinations were made of: body weight, body temperature, number of red blood cells, and presence or absence of avian tuberculosis or pullorum. In addition cloacal cultures were made to test for bacterial infections of the lower bowel. (In the first study these determinations were made on the sixth and thirteenth days of the stress period.) Post-mortem examinations were made on all birds that died.

The average length of time a bird survived the stress was determined on the basis of actual and estimated survival times. In the first study, birds were subjected to the stress until they died. However, after these data were analyzed, it became apparent that the survival time of the birds in any one group could be estimated before all of the birds had succumbed to the stress.

The stress period was in most cases continued until some birds in each treated group had died. The following number of birds died from the applied stress during each study: July 1950, all birds; October, 5; December, none; January 1951, none; February, 1; April, none; May, 2; June, 3; July, 6; August, all.) The survival time of the remaining birds was estimated on the basis of the rate of weight loss prior to reaching an average "mortality level" of 500 gms. (The average weight at death of all birds that succumbed to the applied stress throughout the year was 439 grams; averages for each study period ranged from 384 to 510 grams.) The rate of daily weight loss was computed for each group of experimental birds from the difference between their starting weight and 800 grams, and between 800 grams and 500 grams (Table 2). Using these rates of weight loss, we computed the number of days each bird which was alive at the end of the stress period would have lived had it reached the mortality level of 500 grams. This figure was added to the number of days the hen had lived since the beginning of the stress. The sum of the two gave a figure that was an estimate of the length of time the bird would be expected to live under continued stress. An estimated survival time in days for a particular stress period was then determined by averaging all survival times, both actual and estimated, for the birds in the group under study.

**Table 2**

**Average Daily Rate of Weight Loss of Pheasant Hens Under Applied Stress**

| Month | Starting Weight to 800 Gms. | 800 to 500 Gms. |
|---|---|---|
| July 1950 | 24.8 gms. | 34.5 gms. |
| October | 22.2 | 30.8 |
| December | 13.8 (wild: 19.0) | 27.6* (wild: 44.7) |
| January 1951 | 17.5 (wild: 17.7) | ---- (wild: 31.9) |
| February | 13.8 | 22.5 |
| April | 14.1 | 23.1 |
| May | 28.4 | 31.7 |
| June | 24.8 | 48.1 |
| July | 21.4 | 28.7 |
| August | 21.9 | 34.7 |

*one bird

Although this method of estimating stress survival is not a completely precise one, we believe that it is adequate to provide a means of comparing the potential survival of the different groups of birds without waiting for each hen to die. The averages of weight loss and survival time of hens in each study appeared great enough to show relatively large mean differences. This procedure also saved a large number of pheasants which could be used for other types of experiments at the game farm.

# RESULTS

## Seasonal Response of Game Farm Breeder Pheasants to Applied Stress

In this section, the results of the stress studies involving the game-farm-pheasant hen (from the group of July 1950 spent breeders) will be presented. All birds used in this part of the study were adult hens except for the December and January groups which were composed of immature game-farm hens. In order to present a clear picture of the relationship between survival time and the season of the year, consideration of such factors as molting, age, etc. will be excluded from this section. A few general comments will be made on the condition of the birds to provide a background for more detailed discussion later.

Data on the response to the applied stress and survival time are presented in Table 3 and Figure 1.

## Table 3

### Seasonal Response of Game-Farm-Breeder Pheasants to Applied Stress

| | Molt Period | Advanced-Molt Period | Midwinter Period[5] | | Late-Winter Period | Pre-Egg-Laying Period | Egg-Laying Period | | Molt Period | |
|---|---|---|---|---|---|---|---|---|---|---|
| | July 1950 | Oct. 1950 | Dec. 1950 | Jan. 1951 | Feb. 1951 | April 1951 | May 1951 | June 1951 | July 1951 | Aug. 1951 |
| Number of birds | 46 | 6 | 16 | 15 | 11 | 12 | 6 | 13 | 16 | 16 |
| Av. starting weight in gms. (and per cent weight gain or loss)[1] | 816<br>------ | 954<br>(+17) | 1008<br>(+6) | 1090<br>(+8) | 1047<br>(-4) | 1134<br>(+8) | 1078<br>(-5) | 1015<br>(-6) | 900<br>(-11) | 861<br>(-4) |
| Est. av. survival (days) | 13 | 21 | 27 | 29 | 34 | 40 | 22 | 17 | 18 | 13 |
| Av. weight in gms. (and per cent weight loss) in 7 stress days[2] | 639[3]<br>(22) | 792<br>(17) | 908<br>(10) | 1001<br>(8) | 935<br>(11) | 1035<br>(9) | 853<br>(21) | 831<br>(18) | 716<br>(20) | 681<br>(21) |
| Av. weight in gms. (and per cent weight loss) in 14 stress days[2] | 513[4]<br>(37) | 694<br>(27) | 808<br>(20) | 898<br>(18) | 875<br>(16) | 939<br>(17) | 764<br>(29) | 702<br>(31) | 591<br>(34) | 500<br>(42)[6] |
| Av. starting body temperature | ------ | 108.9 | 107.7 | 107.8 | 107.2 | 107.1 | 108.1 | 107.7 | 108.3 | 108.2 |
| Av. body temperature in 7 stress days | ------ | 108.0 | 108.3 | 108.1 | 107.8 | 108.0 | 107.3 | 107.4 | 108.0 | 107.2 |
| Av. body temperature in 14 stress days | 98–100 | 107.4 | 107.9 | 108.0 | 107.0 | 107.7 | 107.0 | 106.5 | 105.1 | 105.8 |
| Pathology | Salmonella organisms | None | None | None | None | None | Salmonella organisms | Salmonella organisms | None | None |

[1] Percentages express weight gain or loss from previous period
[2] Percentages express weight gain or loss from average weight at beginning of study
[3] Six days of stress
[4] Thirteen days of stress
[5] Immature pheasants used
[6] Estimated

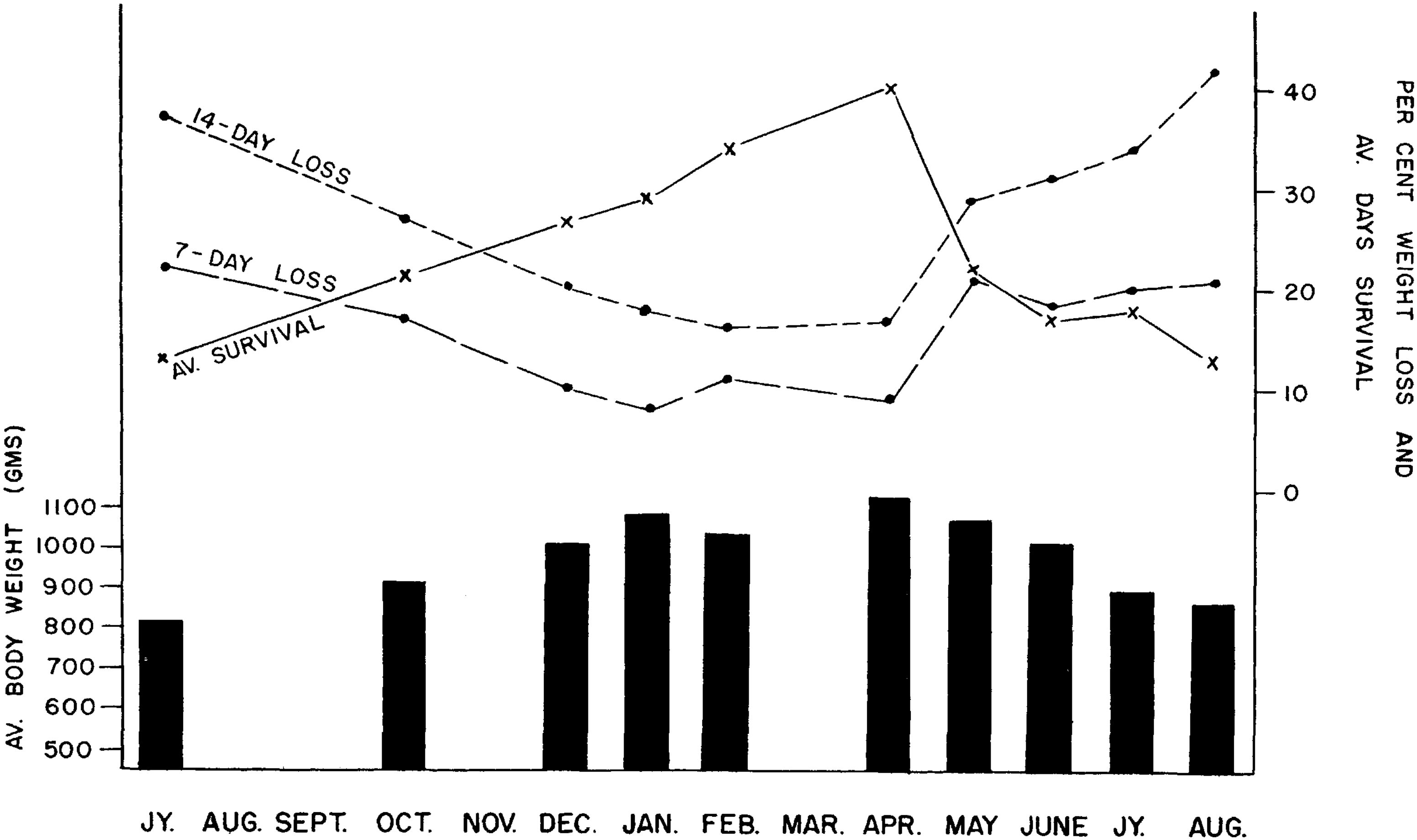


**Figure 1. Seasonal response of breeder hen pheasants to applied stress.**

## Molt Period—July 1950

In this study, spent breeders were used which had stopped or were about to stop laying. They were in various stages of the post-nuptial molt of the primary flight feathers—some had not yet started to molt and some had already molted their first 3–5 primaries.

In the summer following egg laying and during the early stages of the molt the game-farm hen's weight was the lowest observed for the year (816 gms.). Response to caging and starvation showed that the hen had little ability to withstand the applied stress—as shown by an average survival of 13 days. Peak mortality occurred between the 10th and 13th days of stress.

The per cent weight loss from stress for this group was the highest for the year (1950). After 6 days of combined caging and starvation, the hens lost 22 per cent of their body weight, and after 13 days, 37 per cent.

Statistical analyses were made of the data from the first study to obtain some information about the relationship between weight and survival. The analyses showed that the relationship which existed between the weight loss after 6 days of stress and survival time was highly significant (Fig. 2). Those birds losing the most weight in the first 6 days had the shortest survival time. A significant relationship also existed between starting weight and survival time (Fig. 3) which demonstrated that the heavier the bird was at the beginning of the experiment, the longer it survived the applied stress.

Body temperature determinations which were made on a small random sample of the July hens showed that the hen's body temperature began to drop from its normal range of 107–109° on about the 5th day of stress to 98–100° on about the 13th day, at which time the birds were dying.

The majority of the birds did not show any marked outward change in appearance until the 6th or 7th day of stress. At this time their feathers became very ruffled and the birds stood motionless in a hunched position.

During the applied stress period, most of the birds which had already started to molt their primary flight feathers continued to molt an additional primary, while only a few of those birds which had not yet started, began their molt.

When bacteriological examinations were made of each of the hen pheasants as they died during the applied stress, bacteria of the Sal-

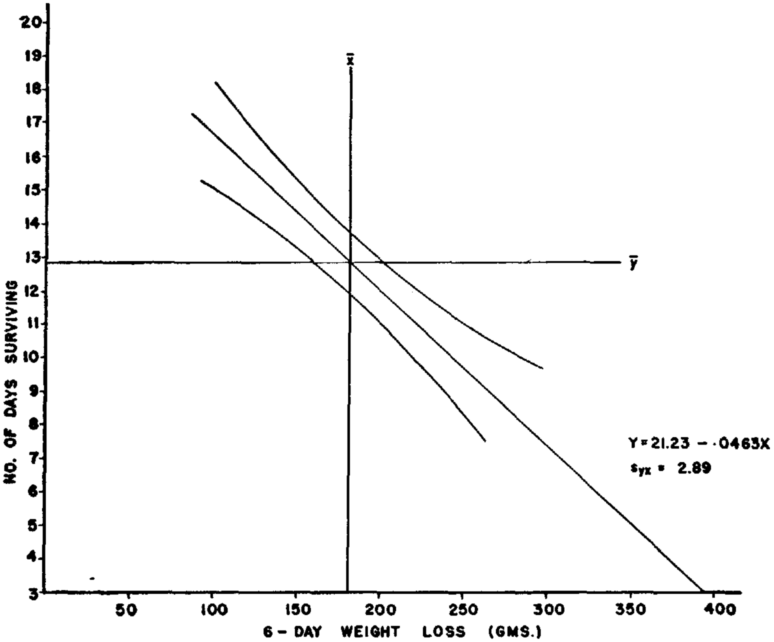


**Figure 2. Relationship between weight loss and survival time after six days of stress—spent-breeder hens, July 1950 *(highly significant at the 99 per cent* level of confidence).**

monella (paratyphoid) group were isolated from the livers and intestines of 37 per cent of the birds. These infected hens showed mild to moderate intestinal inflammation.

## Advanced-Molt Period—October 1950

In October, about two and one-half months after the cessation of egg laying, the birds were in an advanced stage of the post-nuptial molt of the primary flight feathers. By this time, they had gained 17 per cent of the July weight. The length of time they survived caging and starvation also rose to 21 days, an increase of 8 days over the July period. The increase in weight, however, was relatively unstable, for the October hens lost the weight they had gained since July (17 per cent loss) in only 7 days of applied stress, and lost 27 per cent of their body weight in 14 days of stress. Although the hens lost weight readily in October, the per cent loss was less than that shown by the hens in July during like periods of stress.

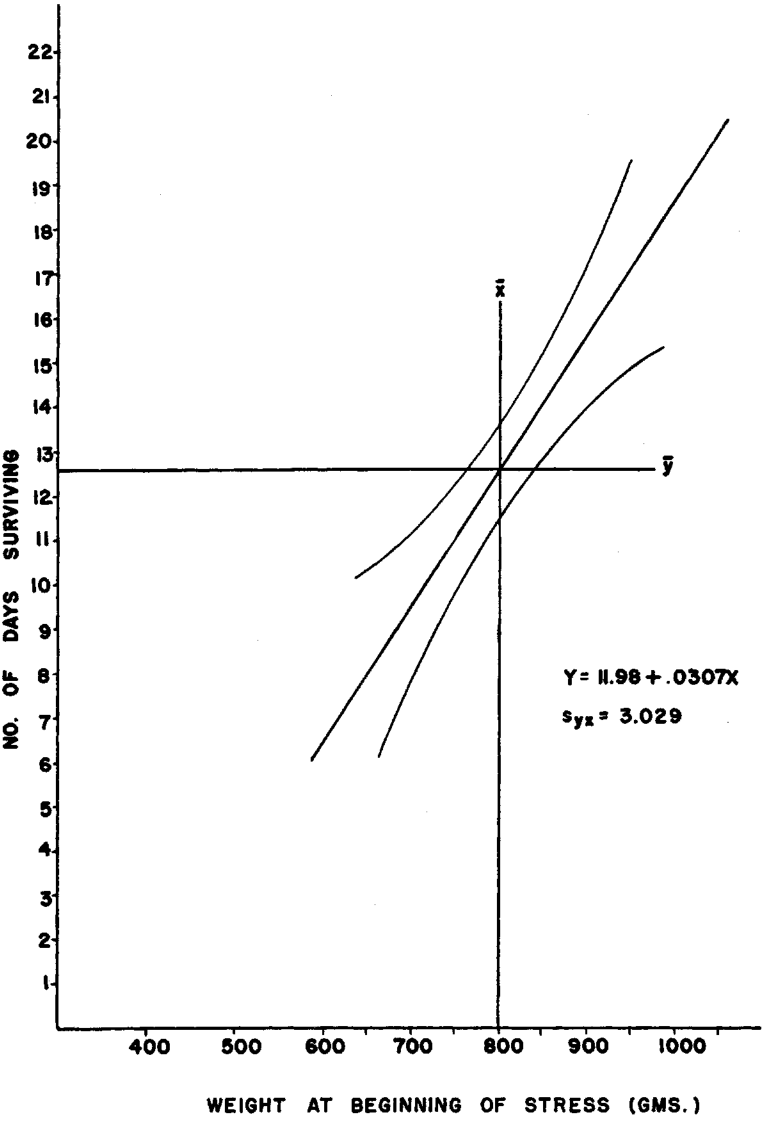


Figure 3. Relationship between weight at the beginning of stress and survival time—spent-breeder hens, July 1950 (significant at the 95 per cent level of confidence).

Post mortem examinations of the hens which succumbed during the stress failed to reveal the presence of any disease or significant parasitism.

## Mid-Winter Period—December and January 1950–51

Although the birds used in the December and January experiments were immature game-farm hens, their stress response generally paralleled that of the adult hens in the preceding and following months. The average weights of these groups of immature birds at the beginning of the stress were 1008 and 1090 grams respectively, showing a continuation of the weight increase which had been observed since July in mature birds. The ability of the birds to withstand the applied stress was demonstrated by a survival time of 27 days in December and 29 days in January. The per cent of weight lost after 7 and 14 days of stress continued to decrease. By January the 7-day loss of weight during the applied stress was at a minimum for the year.

At the beginning of the December experiment, 14 pheasant hens were sacrificed and examined for pathology, disease and parasitism. All birds appeared to be free of disease. At the end of the applied stress, all of the pheasants were found to be free of avian tuberculosis, pullorum infections, general Salmonella infections and blood parasites.

## Late Winter Period—February 1951

The breeder hens used in the February studies showed some evidence of picking when they were taken from the game farm runs. An outbreak of picking also occurred during the stress period.

In this late winter period, the pheasants showed a slight decline in weight, amounting to 4 per cent of the January weight. Their average survival time however was 34 days. The per cent weight loss after 7 days of starvation and caging increased slightly over the January hens, but the per cent weight loss after 14 days of stress decreased slightly.

Post-mortem examination of birds which died during the stress showed no disease or parasitism.

## Early Spring Period Prior to Egg Laying—April 1951

In the period from February to a time just prior to egg laying, the hens showed an increase in body weight (8 per cent of their February weights). In early April they averaged 1134 grams—the highest average weight recorded for the year. The ability to survive caging and starvation increased to a peak of 40 days. The per cent of weight lost during the stress was within the lowest ranges shown by the hen pheasant throughout the season.

The April hens maintained their normal body temperatures during 21 days of stress.

Tests for avian tuberculosis, pullorum disease, parasitism and infections of the lower bowel made at the beginning, during, and at the end of the stress period were negative.

## Egg-Laying Period—May, June 1951

In early May, approximately two weeks after the hens had begun to lay, their weight had decreased only 5 per cent from the peak weight observed in the April pre-egg-laying period. However, in response to the applied stress, they showed a great decrease in weight and a concomitant decrease in the number of days they could survive caging and starvation during this period (22 days, or 18 days less than the April hens).

The body temperature of these birds decreased one degree in 14 days of applied stress, and then declined further to critically low levels. Salmonella organisms (not *S. pullorum*) were isolated from the cloacae and livers in four of six hens at the end of the stress period. They were found to be free of avian tuberculosis, pullorum disease and parasitism.

In June, the trend in initial weight decline continued (6 per cent of the May weight lost). Survival time also decreased while the per cent of weight lost under applied stress remained similar to that of the previous month.

## Molt Period—July, August 1951

Following the 1951 egg-laying phase, the spent-breeder hens (in various stages of the molt of their primary flight feathers) continued to show a decline in their natural weight, until in August they again approached the low weight which was observed at the end of the egg-laying period in July 1950. In August, the length of time the hen was able to survive the applied stress dropped to the 13-day minimum.

The per cent weight loss during 7 days of stress remained at about the same high level which had been characteristic since May, while the loss during 14 days of stress increased to a maximum of an estimated 42 per cent of the August weight.

## Relation of Various Conditions to Stress Response

In several of the seasonal stress studies, the relation of wing molt, age, time of hatch, and physical condition to seasonal stress response was also considered. In some cases additional birds were subjected to caging and starvation along with the game-farm breeders for comparative purposes. The results of these phases of the studies will be presented below.

## Wing Molt

*July 1950 Study.* One of the objectives of this study was to determine if differences in ability to withstand stress could be detected between hen pheasants which began their post-nuptial molt of primary flight feathers early and those which began their molt late.

Spent-breeder hens were separated into three molt groups on the basis of the number of wing primaries molted at the beginning of this study: (1) late (starting) molt group, consisting of hens that had not yet began to molt and those which had molted one primary; (2) intermediate-molt group, consisting of hens with 2 primaries molted; and (3) early (starting) molt group, consisting of birds which had commenced their molt first, and had molted 3, 4, or 5 primaries.

The weight and survival data for each of the three molt groups are given in Table 4. The intermediate-molt group showed the longest survival time, an average of 15 days. The early molters survived 13 days, while the late molters had the lowest survival, 11 days. Within the late-molt group, the "O" molters (birds which had not yet begun to molt) lived only an average of 10 days under stress.

### Table 4
### Response of Pheasant Hens in Various Stages of Post-Nuptial Molt to Applied Stress (July, 1950)

| | Late (Starting) Molt | | | Intermediate Molt | Early (Starting) Molt |
|---|---|---|---|---|---|
| | 0 | 1 | 0 and 1 | | |
| No. birds | 11 | 6 | 17 | 9 | 16 |
| Av. weight in grams (and per cent loss) | | | | | |
| Initial | 794 | 801 | 797 | 807 | 811 |
| 6th stress day | 578 (27%) | 633 (21%) | 606 (24%) | 667 (17%) | 639 (21%) |
| 13th stress day | 559 (30%)* | 513 (36%)** | 536 (33%) | 521 (35%) | 532 (34%) |
| Est. av. survival (days) | 10 | 13 | 11 | 15 | 13 |

*one bird
**two birds

The weight loss during 6 days of stress paralleled the survival time for each group. The "O"-molt hens which showed the shortest survival time, also lost the most weight, while the intermediate-molt group which survived the longest, showed the least weight loss.

*September 1950 Study.* In this special study, which is described in the following section, pheasants with early (starting) and late (starting) molt histories were used, which permitted a comparison of the response of these two groups to applied stress. An additional objective was to determine if the higher survival to applied stress which was shown by the early-molt hens in July could still be demonstrated in September. These data will be presented here for purposes of comparing the stress response of the two molt groups.

Spent-breeder hens which were in advanced stages of post-nuptial molt were subjected to three and one-half weeks of caging, followed by an eight-day period of starvation. The weight changes of the late-molt and early-molt groups during this time are given in Table 5. As the data show, the early molters were slightly heavier than the late molters on July 16. When the two groups were weighed again on September 22 (when the caging period was started), the early-molt hens had gained 15 per cent over their July weight, while the late molters had gained 9 per cent.

After 7 days of caging (stress period A), both the late molters and early molters had lost the weight they had gained in the period from July to September, their average weights decreasing almost exactly to the same levels found during the July molt period.

At the beginning of the starvation period (stress period B), the weights of both molt groups had declined to 830 grams (Table 5), similar to their July 16 level. In the eight-day period of starvation, the early-molt hens lost 31 per cent of their body weight, while the late-molt hens lost 23 per cent of their weight. This difference is significant at the 95 per cent level of confidence.

The average body temperatures of both groups of hens dropped markedly during this period, with the early molters showing a greater average loss than the late molters.

Two birds in each of the groups died during the starvation period.

In summary, at the time when the caging began, the birds in the early (starting) molt group had gained more since July and weighed more than the late molters. This weight advantage was lost during the caging and both groups were at their summer minimum weight levels when starvation was started. During starvation the early molters lost more weight than the late molters throughout the starvation period.

**Table 5**

**Response of Pheasant Hens in Early (Starting) and Late (Starting) Molt to Applied Stress (September–October, 1950)**

| Stress Period | Date and Stress Day | Body Weight (Gms.) | | Body Temperature | |
|---|---|---|---|---|---|
| | | Early Molt | Late Molt | Early Molt | Late Molt |
| A: Overcrowding (21 birds) | July 16 | 845 | 825 | ----- | ----- |
| | Sept. 22 (1st day) | 997 (15% gain) | 908 (9% gain) | ----- | ----- |
| | Sept. 29 (7th day) | 848 (15% loss) | 825 (9% loss) | ----- | ----- |
| | Oct. 6 (14th day) | 839 | 815 | ----- | ----- |
| | Oct. 13 (21st day) | 844 | 825 | ----- | ----- |
| B. Starvation (16 birds) | Oct. 18 (1st day) | 830 | 830 | 109.0 | 108.8 |
| | Oct. 25 (8th day) | 573 (31% loss) | 642 (23% loss) | 104.5 | 105.5 |

## Age

The influence of age on the hen's ability to withstand applied stress was investigated in the February 1951 study. Immature hens along with the adult (two-year-old) game-farm hens were subjected to combined caging and starvation. The results of this phase of the February study are presented in Table 6.

At the beginning of the experiment, the adult birds averaged about 100 grams more than the immatures. Although the per cent of weight lost during the three-week stress period was almost identical for both groups of birds, the adult birds showed a higher survival than did the immatures. The body temperatures of the adults remained the same, while the immatures lost 0.7 of a degree after three weeks of stress. Five immatures died as a result of stress, but only one adult succumbed.

**Table 6**

**Response of Adult and Immature Pheasant Hens to Applied Stress (February, 1951)**

| | Adults | Immatures |
|---|---|---|
| No. birds | 11 | 25 |
| Av. weight in grams (and per cent loss): | | |
| Initial | 1047 | 952 |
| 7th stress day | 935 (11%) | 844 (11%) |
| 14th stress day | 875 (16%) | 785 (18%) |
| 21st stress day | 756 (28%) | 666 (30%) |
| Av. body temperature: | | |
| Initial | 107.2 | 107.5 |
| 7th stress day | 107.8 | 108.3 |
| 14th stress day | 107.0 | 107.5 |
| 21st stress day | 107.2 | 106.8 |
| Est. av. survival (days) | 34 | 27 |

## Time of Hatch

*February 1951 Study.* The immature hen pheasants which were subjected to the stress regime in February were from an early 1950 hatch (May 19) and a late 1950 hatch (July 7). Weight, temperature and survival data for the two groups are given in Table 7.

Both groups of pheasants showed some evidence of picking when they were taken from the game-farm runs in February, with the early-hatch immatures appearing to have undergone more picking than the late-hatch birds.

In the third week of the stress an outbreak of picking occurred among the early-hatch birds despite the de-beaking procedures which were employed to safeguard against such a situation.

The early-hatch immatures averaged about 100 grams more than the late-hatch birds at the beginning of the study. The per cent of weight loss and body temperature decline during the three-week period of caging and starvation were essentially the same for both groups. Three birds succumbed to the stress in the late-hatch group, and two in the early-hatch group.

*June 1951 Study.* In the June study, the response to stress of early-hatch hens and late-hatch hens was again compared (Table 7). The late-hatch birds lost more weight and showed a shorter average survival time than did the early-hatch birds.

The findings of the February study showed little difference between the two groups, but those of the June study suggested that birds hatched earlier in the spring may be superior to those hatched later in the season in their ability to withstand stress.

**Table 7**

**Response of Pheasant Hens from Early and Late Hatches to Applied Stress (February and June, 1951)**

| | February | | June | |
|---|---|---|---|---|
| | Early Hatch | Late Hatch | Early Hatch | Late Hatch |
| No. birds | 13 | 12 | 7 | 6 |
| Av. weight in grams (and per cent loss): | | | | |
| Initial | 1000 | 898 | 1028 | 1004 |
| 7th stress day | 883 (12%) | 800 (11%) | 860 (16%) | 803 (20%) |
| 14th stress day | 803 (20%) | 763 (15%) | 743 (28%) | 662 (34%) |
| 21st stress day | 705 (30%) | 649 (28%) | ---- | ---- |
| Av. body temperature: | | | | |
| Initial | 107.6 | 107.4 | 107.5 | 107.5 |
| 7th stress day | 108.2 | 108.2 | 107.2 | 107.2 |
| 14th stress day | 107.3 | 107.7 | 106.8 | 106.1 |
| 21st stress day | 106.9 | 106.7 | ---- | ---- |
| Est. av. survival (days) | 28 | 26 | 21 | 17 |

## Physical Condition

The objective of part of the December and January study was to compare the response to applied stress in wild and game-farm birds. However, since the wild birds used in these studies showed a lower average weight than the game-farm hens, there was an opportunity rather to investigate the possible effects of physical condition on the bird's ability to withstand applied stress.

In the December studies, wild hen pheasants (immatures) which had been trapped in Dane County were used, with the game-farm immatures as controls. In January, the experimental group consisted of wild immature hens trapped in Milwaukee County (with the game-farm immatures as controls). Both groups of wild birds were subjected to starvation and overcrowding as soon after their capture as possible.

All of the wild pheasants were allowed to succumb to the applied stress as a means of determining actual survival in these two groups.

After 18 days of stress, both of the game-farm control groups were given feed. At this time the required weight and body temperature data were obtained so that average survival times could be estimated. The data from these studies are presented in Table 8.

Fourteen Dane County pheasants were sacrificed and autopsied soon after being captured. They all appeared to be well nourished. However, seven of these birds exhibited a mild to moderate enteritis which was localized in the duodenal portion of the small intestine. It was believed at first that these birds might have had a chronic form of fowl cholera. However, cultures were taken from the lungs, spleen, and liver of each of the 14 Dane County hens examined, and the bacterium *Pasteurella multocida* (the causative agent of fowl cholera) was recovered from only two of these birds.

A similar number of game-farm controls were also sacrificed and examined for internal pathology, disease, and parasites. No evidence of disease was found.

The initial weights of the Dane County and the game-farm birds were similar. Loss in body weight after 7 days of stress was also similar. After 14 days, however, weight loss increased in the Dane County group. After 18 days of stress, 11 of the 16 Dane County birds had died, but none of the game-farm controls had succumbed.

In the January study, the Milwaukee County birds averaged 200 grams less than the game-farm controls. This group of wild birds also showed greater weight loss and body temperature decline under stress than the game-farm controls. Eleven of the 15 birds died in 18 days of stress, while none of the controls succumbed.

Samples of both the Milwaukee County and game-farm hens which were examined for disease and parasites soon after being captured were found to be free of any sign of pathology. However, the sample of the Milwaukee County hens which were sacrificed just prior to the start of this study was examined and found to be poorly nourished.

Daily observations were made of the comparative behavior of the wild pheasants and the game-farm controls during December and January. There was no noticeable difference in the behavior (amount of activity, nervousness, combativeness, and attempts to escape) of the wild pheasants and the game-farm controls in the initial days of stress. Beginning with the 10th and 11th days of stress, the wild pheasants began to become visibly affected by the stress as demonstrated by the ruffled appearance of their feathers and less general body activity. The controls failed to show any noticeable change in behavior throughout the 18-day period.

These data are interpreted to mean that both groups of wild birds had been undergoing the natural stress of a mild disease condition and/or malnutrition which decreased their ability to resist the applied stress.

Comparisons of both groups of "wild" pheasants (the Dane County and Milwaukee County birds) show that each group had about the same capacity for resisting stress.

**Table 8**

**The Effect of Physical Condition on the Pheasant Hen's Ability to Withstand Applied Stress (December and January)**

| | Dane County | | Milwaukee County | |
|---|---|---|---|---|
| | Wild Hens* | Controls | Wild Hens** | Controls |
| No. birds | 16 | 16 | 15 | 15 |
| Av. weight in grams (and per cent loss): | | | | |
| Initial | 1001 | 1008 | 877 | 1090 |
| 7th stress day | 891 (11%) | 908 (10%) | 775 (12%) | 1001 (8%) |
| 14th stress day | 689 (31%) | 808 (20%) | 618 (30%) | 898 (18%) |
| Av. body temperature: | | | | |
| 7th stress day | 108.1 | 108.3 | 108.0 | 108.1 |
| 14th stress day | 106.1 | 107.9 | 106.2 | 108.0 |
| Est. av. survival (days) | 19 | 27 | 16 | 29 |

*Mild disease condition present
**Undernourished

## Response to Caging as a Stress

In the seasonal studies, caging and starvation were treated as a single applied stress used to evoke a response in the hen pheasant. In order to measure the effects of caging alone as a stress and the effects of caging followed by starvation, a separate study was conducted in September, 1950.

Spent-breeder hens which were in advanced stages of primary-feather molt were confined to cages (those used in the previous studies) for three and one-half weeks (stress period A). During this time the birds received ample food and water daily. Following this period, a group of these same birds was subjected to an additional eight-day period of starvation (stress period B).

As a result of caging, the birds' weight declined in 7 days to an average of 834 gms., which closely approximated their average weight in July, when they had just finished laying eggs and were beginning their molt (Table 9). Despite having all the feed they wanted to eat they did not regain the weight they had lost, but continued to lose slightly over the next 7 days. After two weeks of caging, the birds appeared to be slowly gaining weight. Their body temperature remained about the same. All hens survived this period of stress. Caging did not appear to markedly upset feeding habits. Actually, under these conditions they did not need as much energy, since there was no competition for food, or opportunity for exercise and movement.

After 8 days of starvation, following the caging period, the birds rapidly lost weight (27 per cent of their weight at the beginning of starvation), and 4 degrees of body temperature.

**Table 9**

**Response of the Hen Pheasant to Caging Followed by Starvation**

| Stress Period | Date and Stress Day | Average Body Weight | Average Body Temperature |
|---|---|---|---|
| A: Overcrowding (21 birds) | July 16 | 832 | 109.4 |
| | Sept. 22 (1st day) | 942 | 109.5 |
| | Sept. 29 (7th day) | 834 (11% loss) | 109.1 |
| | Oct. 6 (14th day) | 824 | 108.9 |
| | Oct. 13 (21st day) | 833 | ----- |
| B. Starvation (16 birds) | Oct. 18 (1st day) | 830 | 109.0 |
| | Oct. 25 (8th day) | 608 (27% loss) | 105.1 |

It appears that caging acts as a moderate stress, causing the birds to lose weight to the level characteristic of the spent breeders during the molt period. Only slight further loss occurred, suggesting that some adjustment mechanism apparently operated to prevent further decrease in weight after about a week. However, the failure to regain the weight lost suggests that caging continued to be a mild stress. The application of starvation to the caging stress caused a more rapid loss of weight in the same time interval than was shown by other groups of birds that had been subjected to a starvation treatment with no prior caging. In fact, the weight loss of the birds subjected to caging first lost as much weight in an 8-day starvation period as did the October group of hens (Table 3), which had no prior caging, during a 14-day period. Further, the caged birds lost a greater percentage of their weight during a 7-day period than did birds that were starved in midwinter.

Caging alone appeared to constitute a stress comparable to that caused by such natural factors as egg laying, molting, etc., which were associated with the decline of pheasants weight to a minimum level in July and August. The July birds which had just finished laying eggs and had started their molt, and the group which had been caged for 21 days lost weight at comparable rates while being starved for approximately one week.

## DISCUSSION

The pheasant hen is a living machine that runs on a yearly schedule which is determined to a large extent by the environment. Perhaps her "toughest" period is during the reproduction season when she must go through the rigors of courtship, nesting, egg-laying, incubation, brooding of young and subsequent molt. At all seasons of the year she must face changes in weather, possible food shortage, enemies and a host of other conditions attendant upon life in the wild.

Which of these factors causes more wear and tear on the hen? Does the physiological condition of the hen change throughout the year as a result of some of these factors? Is she therefore more "susceptible" to further hardships at different seasons?

The experiments described in this paper were undertaken in an attempt to gain a better understanding of factors affecting pheasant mortality. The objective was to select an easily controlled, artificial stress which would serve to bring out seasonal changes in the resistance potential or reserve ("adaptation energy" of Selye, 1949) of the hen pheasant to adverse conditions. Body weight loss, body temperature decline and average survival time were used as criteria to measure the response of the bird to the applied stress.

According to the Selye concept, when an organism is subjected to any kind of stressful agent, specific or nonspecific reactions develop which make the animal resistant. The reaction which causes the body to become resistant only to a specific stress is called *specific adaptation,* whereas resistance against other stresses which are qualitatively different from the original one is termed *nonspecific* adaptation. Muscle hypertrophy produced by exercise and antibodies developed in response to antigens are examples of adaptations to specific stresses. Examples of nonspecific stresses are inanition, trauma, and hypoxia. These stresses all stimulate about the same kind of responses or adaptation. The sum of all these nonspecific responses to prolonged stress Selye (1949) has characterized under the term "General Adaptation Syndrome".

The General Adaptation Syndrome is a series of responses which can be divided into three stages: (1) The first is the *alarm reaction,* which can be subdivided into the *shock* and *counter-shock* phases. During the shock phase the main symptoms are decreased body temperature, hemo-concentration, depression of the nervous system, tissue catabolism, decreased metabolic rate, and increased capillary permeability, amongst others. If death does not occur during the shock phase, the animals begin to recover by means of responses which are grouped under the term *counter-shock.* During this phase ACTH secretion is released in larger amounts and there is, as a result, an increased secretion of adrenal cortical steroids. During counter-shock the "direction" of the symptoms characterizing shock are reversed and resistance to the stress develops and increases.

(2) In the face of continued and severe stress no animal can live indefinitely in the alarm stage, and will die during this stage. If the stress is less severe or the resistance responses which are developing during the counter-shock phase are great enough, resistance or adaptation to the stress increases and the animal survives. During this stage, which is called the *resistance or adaptation stage,* resistance to the agent causing injury is increased beyond that developing in the counter-shock phase, but resistance to other types of stress is not increased and usually is decreased. The output of adrenal steroids is increased.

(3) Resistance or adaptation to prolonged stress cannot be maintained indefinitely. The acquired adaptation is lost and the animal dies while showing symptoms very much like those of the shock phase, unless the stress is no longer present. This is called the *exhaustion stage,* and the breakdown of the resistance or adaptive mechanism, according to Selye, is due to the exhaustion of the animal's reserve of *adaptation energy* or its ability to adapt. Adaptation energy can be regenerated during periods of decreased stress, since after such periods the power to adapt to subsequent exposures is restored.

The experimental design in our studies on the hen pheasant was based on the principle that since egg laying, molting, etc. are natural stresses for the hen pheasant, one would expect a lowered resistance to an applied stress such as controlled starvation and/or caging. This assumption is based on Selye's idea that adaptation to a specific stress lowers the body's resistance to different stress to which the animal is not adapted. In the experiments being discussed the applied stress was used as a *means of demonstrating whether there is a seasonal variation in resistance, and which of the naturally occurring physiological stresses causes the greatest decrease in resistance.*

The results of the seasonal stress studies have been summarized in Table 3 and Figure 1, and show definite trends in initial weight, weight loss and survival under the applied stress. The outstanding result was the variation observed in the length of time a bird could survive under a constant stress applied at different seasons of the year. The seasonal change in resistance is probably not a function of time, but of physiological and environmental changes, the former largely determined by the latter.

## Natural Weight Changes

Body weights were at their lowest in July, following the period of egg laying. The birds began to gain immediately after the reproductive phase and continued to gain through January. A slight loss occurred in February, but in April just prior to the onset of egg laying the hens reached their peak weight for the year. Weights declined slightly in May and continued to decrease until the low was again reached in late summer.

The diet of the hens which were being held for the stress experiments consisted of pelleted laying ration, except during the period from November to mid-February when they were fed a high caloric diet of corn and wheat. However, we did not observe any effect of the change in diet on the steady trend in weight increase which occurred from October to April.

These seasonal changes are like those reported by other workers. Kirkpatrick (1944), who followed the weights of hen pheasants every month during the first two years of their lives, observed a decrease in weight to the 800–900 gram level in August following the first breeding season, with a subsequent gain in weight during the fall and winter months. In their Wisconsin studies, Kabat *et al.* (1950) found that the average weight of the adult hen pheasant was lowest in July, higher in December, at which level it remained until early February when it increased to peak weights in March (the end of the study).

This general trend in the seasonal weights has been observed in a number of species. Bennett (1938) found that adult female blue-winged teal were heaviest in the spring and lightest in weight during July and August. Mosby and Handley (1943) observed that wild turkeys weighed the most in late winter and early spring, and the least in late summer. In red grouse peak weights are reached in April and May, and the lowest values in June and July (Wilson, 1911). However, the weight increase during the fall and winter showed more variation than that observed in the other species mentioned above.

## Seasonal Changes in Stress Resistance

Resistance to applied stress, as measured by weight loss and survival time, also varied at different seasons of the year. This variation is related to the natural weight of the bird and to its physiological condition. The underlying relationship is one of energy—"adaptation energy" required and used. Special demands for energy are placed upon the hen pheasant by both inherent and environmental stresses—e.g. reproductive activity, molt, cold and heat, disease, etc.

An approximation of the energy requirements of the hen at different times of the year can be calculated from the amount of weight lost as a result of starvation. As an aid in discussing these energy relationships, we converted the actual weight lost in grams into calories. The sources of energy drawn upon by the birds during the applied stress period were primarily fat and protein. Since no food was ingested during stress, it is probable they did not obtain any energy directly from carbohydrates except from those stored as glycogen.

The total amount of fat present in the experimental birds was not ascertained in this study. In a continuation of cerain phases of the pheasant stress studies, Greeley (1953) weighed the strip of breast fat present on both sides of the keel and demonstrated that the amount of this fat can be used as an index of the amount of body fat. These measurements are shown in Table 10 and provide an index to fat deposition in pheasants throughout the year. Fat stores were relatively low during the summer and fall months, and relatively high during the winter and early spring. The difference between the amount of breast fat in December and January is a little surprising, in view of the body weights observed during these months in the birds in this and other studies. However, the periods of high and low weight levels generally parallel the weights recorded in the experimental birds used in the present study (Fig. 1). Furthermore, the parallelism between the amount of breast fat and the ratios of fat to body weight suggest that

**Table 10**

**Seasonal Body Weight and Breast Fat Deposition in Hen Pheasants***

| | No. Birds | Body Weight (Gms.) | No. Birds | Breast Fat (Gms.) | Gms./Kg. ** |
|---|---|---|---|---|---|
| January 1955 | 4 | 1020 ± 70*** | 4 | 5.3 ± 1.6 | 5.2 |
| February 1954 | | No Data | | | |
| March | 4 | 1012 ± 41 | 4 | 5.0 ± 0.5 | 4.9 |
| April | 3 | 1032 ± 20 | 3 | 3.7 ± 0.9 | 3.6 |
| May | 4 | 1054 ± 51 | 4 | 3.2 ± 0.9 | 3.0 |
| June | 3 | 912 ± 32 | 3 | 1.0 ± 0.4 | 1.1 |
| July | 4 | 906 ± 52 | 4 | 1.7 ± 0.6 | 1.9 |
| August | 4 | 869 ± 29 | 4 | 1.1 ± 0.2 | 1.3 |
| September | 4 | 846 ± 17 | 4 | 0.3 ± 0.2 | 0.4 |
| October | 4 | 837 ± 21 | 3 | 0.6 ± 0.2 | 0.7 |
| November | 3 | 908 ± 19 | 3 | 0.9 ± 0.1 | 1.0 |
| December | 4 | 944 ± 25 | 4 | 1.9 ± 0.4 | 2.0 |

*From Greeley (1953)
**Mean grams of breast fat divided by mean body weight
***Mean ± standard error of the mean

the seasonal variations in body weight are due primarily to changes in fat rather than changes in protein in the body.

We have arbitrarily set the low summer weight of 800 grams as the level at which very little body fat was present on the hen to provide a reserve store of energy. Any weight above this level was considered as fat deposits. We realize that this may be an oversimplification, but what evidence we have suggests that this is a reasonable approach.

The weight lost in 7 and 14 days of applied stress was then converted into calories—one gram of body fat is estimated to yield approximately 8 calories, accounting for water and connective tissues, and one gram of body protein to yield approximately 0.8 calories, accounting for the water content (Best and Taylor, 1945). Grams of weight above 800 were considered fat, and below 800, protein. Since these birds were full grown, their body weight was assumed to be stable. The results of these conversions of total weight lost into energy used are presented in Figure 4, and are compared to the calculated amount of energy available from fat deposits.

The following discussion is designed to look more closely at the whole picture of the ability of the hen to withstand applied stress throughout the year in relation to its normal weight, physiological condition, and energy demands at different seasons. (This discussion refers to data presented primarily in Table 3 and Figures 1 and 4.) The ideas discussed are presented here only as working hypotheses for the study of this complex problem—and not as proven theories.

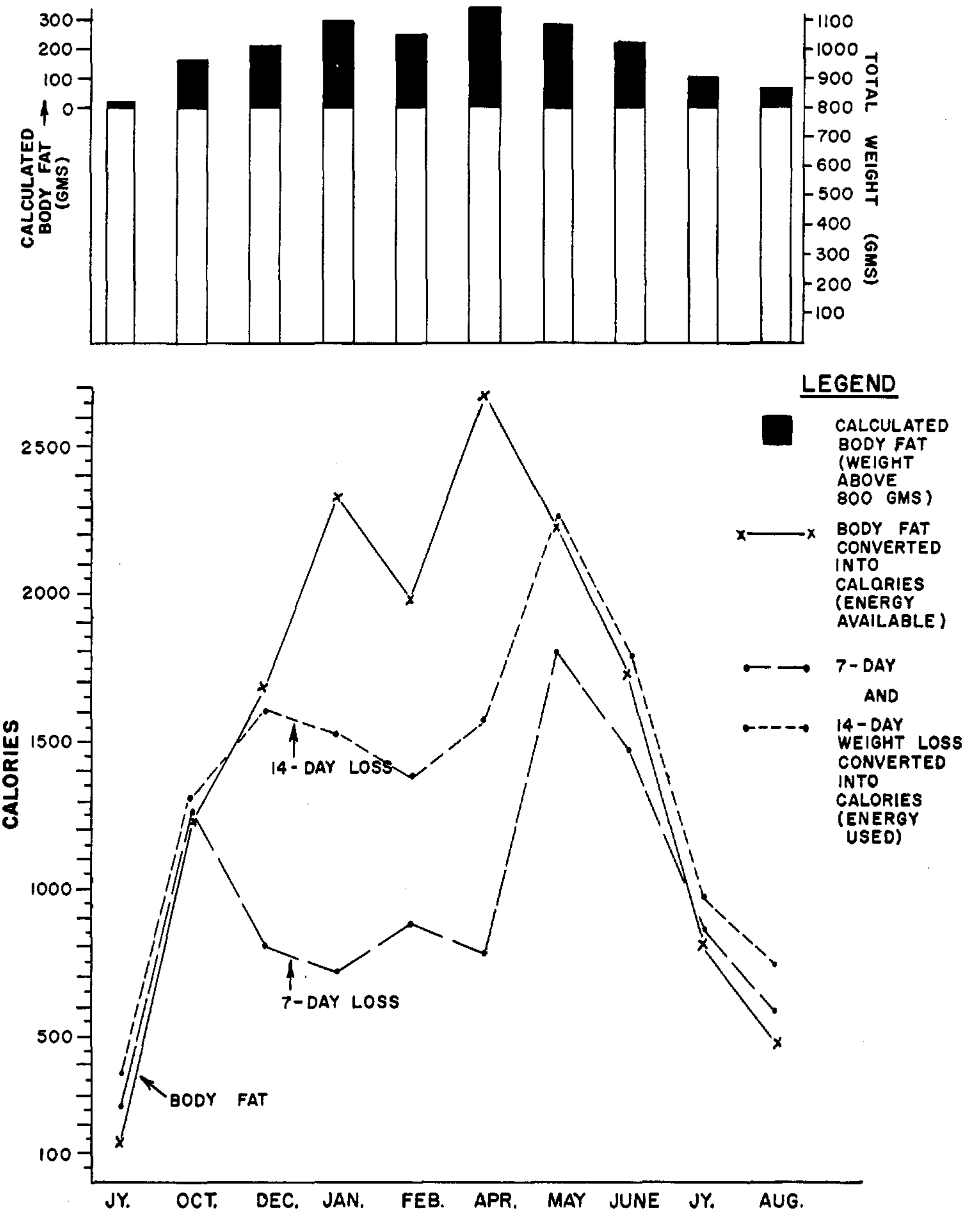


Figure 4. Relation between energy available and energy used in the hen pheasant at different seasons.

Throughout most of the year (July to April) there is a direct relationship between the bird's weight and its ability to withstand applied stress. Following the breeding season and molt, fat reserves are being developed. As weight increases, loss of weight from the applied stress of caging and starvation decreases, and survival is high. Correlation analyses of starting weight and survival data obtained from July birds supports a concept that the heavier the bird is at the beginning of the experiment, the longer it survives applied stress. Likewise the wild hens trapped in Milwaukee County (part of the January study, Table 9), weighed about 200 grams less than the game-farm controls, their weight loss under applied stress was proportionately higher, and their survival markedly lower.

In July, the hen pheasants had completed, or nearly completed, egg laying activities, and had begun, or were about to begin, their primary feather molt. In 1950, the birds at this time were at their lowest level of physical condition for the year, as evidenced by their average weight (816 grams). In 1951, however, the low point was not reached until August. The weight at this time of the year appears to represent a natural minimum level which is reached by a bird after a period of moderate stress, either natural or applied.

In the September study, for example, caging was used as a moderate stress factor, and caused the birds to lose weight during the first week of stress to the minimum weight level characteristic of the July birds (Table 9). For the following two weeks the hens remained essentially at this level. However, when the more severe stress of starvation was imposed after the hen pheasants' weight had declined to the natural minimum level, the birds lost weight very rapidly. It is suggested that this loss of resistance is due to a low reserve of energy which is characteristic at this time of year, since fat stores are at a minimum. This rapid loss of weight (the most rapid observed during the year) is probably due to protein utilization; protein would have to be used at a faster rate than fat to provide the same amount of energy in a given period of time. The conversion of protein into energy probably in itself takes considerable energy from the bird which further contributes to rapid weight loss and low survival.

Following egg laying, the birds undergo a post-nuptial molt. The molt of the primary wing feathers was used as an indicator in these experiments of the extent of the entire body molt. Molting is apparently another stress for the hen pheasant, which when superimposed on breeding season stresses further contributes to the low point in body weight and stress resistance for the year. The comparison of the stress resistance and survival of birds in three different stages of the molt (July study, Table 4), demonstrates the sensitivity of the birds to molting. The changes occurring in the bird at the onset of molting appear to impose the greatest stress, for the late molters (those birds which had not yet begun to molt) showed less resistance to the applied stress than did the early molters (those birds in which molt was already in progress).

Although the amount of weight lost was high in July and August, the amount of energy used as shown in Figure 4, was low. This probably means that the available energy supply was exhausted and the "demands" made upon the bird by the applied stress at this season resulted in protein utilization for energy and consequently a short survival time. The burning of fat for energy is like the loss of fenders and bumper from a car—there is no real damage to the mechanism. But the use of protein stores is like "burning up" parts of the car motor—soon it just won't run anymore.

During the fall the hen pheasants showed a marked increase in weight from the summer low, but it was lost after 7 days of applied stress. The sharp rise in the energy used in October reflects this weight increase (fat deposits), and the use of more calories in 14 days of stress than were available in the fat deposits also suggests that the fat store was quickly used up and that the bird was drawing upon protein for energy.

In the winter months, except for February, the hen's natural weight continued to increase, while the per cent of weight lost after 7 and 14 days of stress gradually dropped to a minimum in January. Stability in body temperature during the applied stress period further indicated increased resistance to starvation. This increased resistance can be correlated with the large store of fat which is present at this time. The reserve fat was being drawn upon during this period to provide energy for the bird particularly to combat the environmental stress of cold. This can be seen when weight loss is translated into terms of energy used (Fig. 4). However, it is also apparent from this analysis that the demands of pheasants during the winter period are lower than during late spring and early fall. They are freed from the stress of molting and there is considerable storage of fat which not only provides a ready source of energy but also acts as an insulator which undoubtedly reduces the amount of fat burned for heat energy.

February was characterized by a slight drop in initial weight and a corresponding increase in weight loss rates under applied stress. Survival time, however, continued to increase. An outbreak of picking occurred both before the stress period and during the third week of stress. It is possible that picking may have been the manifestation of some natural midwinter stress, which temporarily lowered the pheasant's resistance to the added stress of caging and starvation. A somewhat similar decrease in weight was noted by Leopold *et al.* (1943) in Arboretum hen pheasants. The birds described in their study reached a peak weight in December, which declined during January and February and then increased in March and April. In the study of Kabat *et al.* (1950), the hens gained weight until December, leveled off until mid-February, and then again showed weight gains.

In April, the hen pheasant apparently reached her peak of physiological fitness. The average weight of 1134 grams was the highest for the year. (Although no studies were made in March, the studies of Kabat *et al.* (1950), Leopold *et al.* (1943), Kirkpatrick (1944) and others indicate that the March weights approach the April peak). At this time, just before the beginning of egg laying, the average survival time of the birds under applied stress was the highest for the year (40 days) and the per cent weight lost during 7 and 14 days of stress was at the minimum for the year.

During the fall, winter and early spring until the time when the hen began to lay eggs, there had been a rather close parallel between the per cent of weight gained or lost naturally, the per cent of weight lost under applied stress, and survival time. In May, however, about two weeks after the start of egg laying, a striking deviation from this relationship occurred. The hens lost only 5 per cent of their initial April weight, but they showed a marked decrease in survival time and a marked increase in the per cent of weight lost after 7 and 14 days of stress.

Egg laying together with other attendant physiological changes must make tremendous energy demands upon the hen pheasant. This is reflected in the marked rise in energy used as shown in Figure 4. It is interesting that after about two weeks of egg laying, the hens in the May study still showed only a relatively small loss of initial weight. When subjected to the added stress of starvation, however, a significant decrease in resistance was noted in the increased weight loss and decreased survival time. Apparently the hens during this period are able to adapt themselves to the stress of egg laying, but do not have a sufficient energy reserve, or the power to generate energy, to survive starvation as well as birds in midwinter and early spring. This is especially apparent after 14 days of applied stress, when the energy used exceeded the fat energy available and again probably represented protein catabolism.

Resistance to applied stress further decreased in June, as egg-laying activities continued to make great energy demands upon the hens.

## Other Factors

During the course of the experiments several other factors were found to be associated with stress resistance and survival—age, time of hatch, and disease. Adult birds survived the applied stress of caging and starvation better than immatures, and birds from an early hatch showed a slight edge in survival rate compared to those from a later hatch. Both the adult and early hatch groups of birds showed higher initial weights, which may have been responsible for their better resistance to the applied stress. These observations also suggest that pheasants which are growing at faster rates than others will have less resistance to stress, because more potential sources of energy available for resistance are being converted into tissue.

The effect of disease on stress resistance and survival is shown by the Dane County birds used in part of the December studies (Table 8). Although these birds weighed about the same as the game farm controls, their ability to withstand applied stress was greatly reduced when compared to that shown by the game-farm birds. This fact is correlated with the higher incidence of disease in the wild birds.

# CONTRIBUTION TO MANAGEMENT AND RESEARCH

Objective research on the role of stresses such as malnutrition, disease, repeated nesting attempts, etc., in wildlife management has been relatively limited in the past. Therefore in pioneering studies on this subject it is necessary to first obtain a considerable amount of basic data through deep digging efforts before a sufficient amount of knowledge is gained that can be used directly in management. Any specific findings which can be used immediately in practical management can be considered as dividends. This study has yielded some dividends as well as basic information on pheasant physiology.

In the following pages, we will briefly point up some of the aspects of our findings that we believe can contribute to practical management, help in the interpretation of population behavior, and form a groundwork for conducting further research both in wildlife and related fields.

# Management Application

## Winter-Feeding Programs

The value of winter-feeding programs in which harvested grain is supplied at feeding stations has sometimes been questioned. Gerstell (1942), for example, observed that pheasants could live for approximately one month without food in winter. He therefore deduced that winter feeding was unnecessary, since the periods of deep snows which make food unavailable rarely extend for 30 or more days.

The results of our studies, however, suggest that a relatively constant supply of available food of high caloric value throughout the winter may be paramount to high survival and successful reproduction efforts. Several lines of evidence lend support to this contention.

If food is readily available, pheasants generally move very little each day. Their movement during cold weather, particularly if the snow is deep, is limited to a short trip to the nearest food source from their night roost in the early morning and another short trip to a feeding spot in the late afternoon. However, in unpublished studies we observed that in pens 25 by 75 feet in size, which were large enough to allow a certain amount of movement, pheasants showed signs of extreme emaciation within a two-week period when held without feed. Also, the results of the experiments reported here indicate that the daily energy requirements of pheasants are high. Thus pheasants in the wild might be expected to wander about in search of food if their movement was unrestricted and food was not readily available. This behavior would result in a great expenditure of energy and at the same time a high food requirement.

Malnutrition resulting from lack of available food and/or excessive expenditure of energy can have several effects upon the pheasant. There can be outright starvation, or a greatly reduced ability of the pheasant to resist an added stress such as disease which might otherwise be tolerated. In our studies lowered resistance to added stress was observed in the Milwaukee hens which were poorly nourished (Table 8). Of perhaps even greater significance are the possible consequences of the reproductive period on a hen in poor physical condition. Normally, when egg laying starts, hens have developed large fat reserves. These are drawn on heavily for energy during the laying season. It is logical to assume that if the hen failed to get an abundance of food in the winter she would enter the taxing period of egg laying deficient in fat reserves, and could be expected to have low resistance to various mortality factors. Furthermore the reproductive ability of the hen may be affected by her physical condition. Earlier experiments in Wisconsin have shown that pheasants held without food for a period just prior to egg laying had a lower rate of egg production than hens that were not deprived of food (Kozlik, 1949).

Other research on the effects of an applied stress on Hungarian partridge (Flakas, 1951) showed that these birds survived for only 10 days without food in February. The necessity for a sustained supply of available food is apparently even more important in this species.

Severe winters causing extreme food shortages in 1942–43, 1947–48, and 1950–51 reduced quail and Hungarian partridge in Wisconsin to the extent that three to five years of good hatching conditions and survival were required before their populations recovered. Many of the birds observed during these winter periods starved and it is logical to assume that the surviving birds were in relatively poor breeding condition. The occurrence of adverse weather during the spring at nesting time in any one of these years would result in further stress on the already weakened breeders.

These stress studies on pheasants and Hungarian partridge point up the need for winter feeding programs during extreme winters. Although birds may survive a relatively long time without food, the lack of available food could easily result in weakening them so that they not only are less able to withstand additional stresses of the environment, but they also enter their strenuous role as breeders in poor physical condition. If the natural habitat fails to provide sufficient food, it appears possible that highly developed emergency winter-feeding programs could greatly reduce annual losses both during the winter and in the following spring and summer. Even in good natural habitat there will be many coveys or flocks of upland game birds which may be isolated from accessible feeding sites. Winter feeding has been carried out by conservation departments in the past, but in many instances the intensity of these efforts has been limited.

Winter feeding, however, must not be considered as a substitute for habitat improvement or the maintenance of good natural habitat. The more inferior the habitat, the greater will be the need for emergency winter feeding.

## Habitat Management

Although this study does not contribute new information concerning our present knowledge of the general value of good habitat in farm game management, it does serve to show more specifically how important habitat is in maintaining wildlife populations. The high energy requirements of pheasants, their natural proclivity for moving short distances to feeding sites and the effects of stress upon them just before the reproductive period indicate the importance of having attractive roosting and feeding spots close together.

Habitat lacking the combination of accessible food and cover cannot be expected to maintain high upland game bird populations. The ability of pheasants to live without food should enable them to survive most storms which cause food shortages if they remained sedentary until the weather ameliorated. Unfortunately they apparently will not remain in one place but will seek food thus using up their energy reserves.

## Artificial Propagation Programs

Birds raised artificially and released into the wild face several difficulties which could act as stresses and affect their survival. In the first place, they undergo a period of adjustment in which they must develop natural feeding habits. Pen-reared pheasants relying upon pen handouts for a long time may lose their ability to forage for natural foods, and in addition may be severely affected by the psychological factor of being released into a strange environment. During this time they will undoubtedly be living on short rations. Failure to release properly nourished game-farm birds in habitat containing immediately available food may cause the liberated birds to move considerable distances in search of food. The extra efforts required along with those normally required for subsistence may greatly reduce survival. It appears important, therefore, that birds intended for release into the wild be placed on a high caloric diet before release to provide them with the maximum opportunity for storing fat.

Secondly, released birds too young to depend upon their own resources for finding food in the wild after their release may also have low survival. Observations of wild pheasant broods in Wisconsin indicate that the young tend to stay with the hen until about ten weeks of age. If the wild adult hen is needed to help care for her brood during this time, similar-aged pen-reared birds could be expected to have less success in foraging for themselves.

Thirdly, pen-reared hen pheasants released in the spring must face in addition to a strange environment and a possible food problem, the approaching reproductive season. This study has shown that egg laying constitutes a great stress on the hen.

The effect of these stresses facing artificially propagated birds may in part explain some of the results obtained in previous studies on an evaluation of pheasant stocking (Kabat *et al.,* 1955). These authors found that well-nourished 10- to 16-week-old pheasant cocks stocked in good habitat in late summer and early fall survived well enough to provide hunters with an average return of 51 per cent. However, further studies on the contribution of adult hen pheasants released in the spring showed that the survival of these birds was low—mortality of about two-thirds of the hens occurring during the spring and early summer. This high mortality could be attributed in part to the effect of the severe stress of egg laying upon the hen, complicated by the possible difficulties imposed by the presence of additional stresses such as the "shock" of release into a strange environment and the lack of easily available food. Attempts were made by Kabat *et al.* to alleviate the problem of an insufficiency of food and sudden release into a strange environment by release of these hens from "gentle release" pens, which were supplied with feed to which the hens could return as they wished after release. However, this effort fell far short of significantly increasing survival.

## Transplanting Exotic or Native Wild Birds

Frequently game departments or private citizens for various reasons wish to transplant exotic or native wild birds to new habitat. Release of such birds in spring prior to their normal egg-laying period can be expected to result in their exposure to the same stresses as described above for pen-reared birds—namely the vicissitudes of a strange environment—at a time when the birds should be attaining their maximum weight before entering the taxing period of reproductive effort. The same low survival as observed for pen-reared hen pheasants can also be expected to prevail. Therefore, it appears logical that transplanting stock should be well fed and should be released in late winter prior to the onset of breeding activities particularly if mild weather prevails and food is accessible. In years when it is necessary to release birds in spring in order to circumvent inclement winter weather, it is especially important to make sure the birds are well nourished and are released in good habitat.

## Improvement of Game Farm Breeding Stock

Wisconsin is now conducting special breeding studies for the purpose of developing hybrid pheasants that are more adaptable to different types of environment in the state. During the course of the stress studies considerable variation was observed between different birds at various times of the year in their response to the applied stress of caging and starvation. With these results in mind, several groups of the experimental hybrids have been subjected to the applied stress treatment described in this report to determine if differences in response to applied stress existed among the hybrids. More study on the use of this technique in special breeding projects is needed, but present results indicate that this technique will help to weed out inferior birds. Such information is especially desirable when efforts in breeding work are concentrated on selection of such characteristics as high fertility, high hatchability, and rapid growth and feather development.

## Interpretation of Observed Wildlife Population Behavior

### Annual Turnover

Most upland game bird populations have a relatively high annual turnover rate (that is, the majority of birds in any one population die from one year to the next). The role of stresses in affecting turnover rates is apparent from previous discussion. When many types of abnormal stresses occur, such as insufficiency of food, unfavorable weather during nesting resulting in renesting efforts, an increase of disease organisms, etc., turnover rates will increase.

### Periodic or Sporadic Population Fluctuations

Christian (1950), in examining the extensive literature on cyclic fluctuations, has proposed as a cause of cyclic decline in mammals the exhausting effect of such stresses as those inherent in a high population level, severe climatic conditions and the demands of the spring breeding season. Our studies suggest that similar relationships may also exist for upland game bird populations.

The possible effects of unfavorable weather during the nesting season on pheasant survival, for example, was brought out in the Wisconsin studies carried on in the early 1940's by Kabat *et al.* (1950). They pointed out that delay of the hatching schedule by adverse weather or some other factor may result in both the production of a relatively small crop of young birds and an increase in the mortality rate of adult hen pheasants.

Summer hen mortality which cannot be accounted for by such direct losses as hay mowing has been indicated in studies of not only pheasants but also quail and ruffed grouse in the wild and may be related to the low resistance and generally poor physical condition of the hen in the summer. Dorney (1955), for example, observed a great decline of ruffed grouse in Wisconsin during 1954–55. His observations revealed that unfavorable weather during the nesting period in the spring of 1954 was followed by a strong distortion of the adult sex ratios (60 per cent males, compared to an average of 55 per cent males during the previous five years), and a poor hatch of young birds.

Since ruffed grouse hens are not exposed to such nesting mortality factors as hay mowing, this distortion of the adult component of the population would appear to be caused by hen mortality due at least in part to the added stress on the hen of extra reproductive efforts (renesting).

The spring of 1955 was very favorable during the nesting season, reproductive success was high, and the 1955 fall grouse population was considerably higher than in the previous year. However, the increase was limited by the "shortage" of adult hens. Since the adults composed a higher than average per cent of the breeding population and the hens existed in relatively low numbers, the spring hatch even under very favorable weather conditions would be proportionately limited by the number of adult hens.

Thus a combination of stress factors occurring in any one or two successive years can reduce a population suddenly and drastically. It is natural to expect the occurrence of adverse weather at least one year in every five- to ten-year period. Since there is a natural limitation to the number of years it takes to recover from a low level to a high level, the ensuing population changes may take the form of the periodic fluctuations commonly described as cycles.

The experimental stress technique can also be used in future studies on wild birds in order to detect variations in survival at different times of the year, between years, or in different areas. Such information might then be related to observed population fluctuations. The response of trapped samples of wild population might show poor resistance to an applied stress in a particular year, revealing the existence of some stress in the wild that had lowered their resistance to the experimentally applied stress. Disease related to malnutrition, for example, might exist in a population, and while not killing the animals, might weaken their resistance to other environmental stress. In such a case management might find it possible to provide extra feed in winter to prevent excessive wandering and the use of extra energy by birds in search of food.

## Use in Other Biological Fields

### Measuring Response of Laboratory Animals to Various Treatments

Investigators in many fields are constantly subjecting laboratory animals to tests in an attempt to determine their reactions to various materials or treatments, such as drugs, antibiotics, hormones, vitamins, etc. In some cases different workers have obtained varied results using the same materials. The disparities might be due to differences in physiological conditions of the laboratory animals particularly if the experiments are repeated at different times of the year. The differential response of hen pheasants to the same treatment of caging and starvation at various times of the year would suggest that laboratory animals too could vary in their response to treatments. This could also be expected to apply in actual cases involving treatment of diseased animals including even human beings.

Stress studies could be carried out in connection with a variety of laboratory or controlled experiments to reveal reactions to certain factors under study which might be demonstrable by lowered resistance, but not necessarily by morphological changes. In nutrition experiments, for example, resistance to applied stress might be an important indicator of the value of different feeds.

## Suggestions for Further Studies

### The Role of Fat Reserves in Stress Response

In this study, hen pheasants showed the greatest resistance to the stress of caging and starvation when they were at their peak weight level. They also showed an annual weight cycle, in which fat reserves increased and decreased periodically. Additional studies are required to determine the role of fat reserves, the relation of feeding habits and fat reserve development, and the mechanics of fat mobilization when the animal is under stress.

### Different Types of Stress Treatments

Caging and starvation treatments elicited a limited response which was revealed over a period of time. One advantage of this type of treatment is of course that the animals can be restored to an apparently normal condition by merely supplying feed. Stress factors that elicit an almost immediate response also appear to be highly desirable. Greeley

(1953) used exposure to low temperatures. Selye (1949) used formaldehyde. Highly toxic stress agents, however, are limited in the extent to which they can be used in wildlife management because of the permanent damage to the experimental animals.

## SUMMARY

1. The experiments described in this paper were undertaken in an attempt to gain a better understanding of factors affecting pheasant mortality. The artificial stress of caging and starvation was selected to bring out seasonal changes in the resistance ("adaptation energy" of Selye) of the hen pheasant to adverse conditions. The experimental design was based on the principle that since egg laying, molting, etc. are natural stresses for the hen pheasant, one would expect a lowered resistance to an applied stress—an assumption based on Selye's idea that adaptation to a specific stress lowers the body's resistance to different stress to which the animal is not adapted. Therefore, the applied stress was used as a means of demonstrating whether there is seasonal resistance variation in adaptation energy, and which of the naturally occurring physiological stresses caused the greatest decrease in resistance.

2. Eleven studies were undertaken at intervals during the period from July 1950 to August 1951, during which groups of hen pheasants were subjected to a standardized artificial stress regime consisting of caging and starvation. The experimental birds were selected for each stress period from a group of one-year-old ring-necked pheasant hens which had been separated in July 1950 from the game-farm breeding stock. In a few cases, wild birds and immature game-farm birds were used for certain phases of the studies. Body weight loss, body temperature decline and average survival time were used as criteria to measure the response of the bird to the applied stress.

3. Definite trends in the hen pheasants' natural weight (initial weight at the beginning of each experiment), the loss of weight from the applied stress, and the length of time they were able to survive the applied stress were observed. The seasonal variation in resistance to the applied stress and survival time was related to the physiological condition of the hen at particular times of the year. A working hypothesis suggesting the relationship between the physiological condition of the hen and energy stores and energy utilization was presented.

In July and August the birds had stopped or were about to stop laying eggs, and were in various stages of the post-nuptial molt of the primary flight feathers. At this time of year the birds were in their poorest physical condition. Their natural weight was at a minimum level (800–900 grams); fat stores were very low which resulted in a low reserve of energy. There was a rapid loss of weight from the applied stress which probably represented protein catabolism, and resulted in a short survival time (13 days).

Following the breeding season and molt, fat reserves were being developed. As weight increased throughout the fall and winter, loss of weight from the applied stress decreased, and survival was high. In the period from February to a time just prior to egg laying in April, the hens reached what appeared from these studies to be their peak of physiological fitness. Their body weight reached a high for the year of an average of 1134 grams. The per cent of weight lost during the stress was within the lowest ranges shown by the hen pheasant throughout the season, and the ability to survive caging and starvation increased to a peak of 40 days.

In early May, approximately two weeks after the hens had begun to lay, their natural weight had decreased only 5 per cent from the peak weight observed in the April period. However, in response to the applied stress, they showed a great decrease in weight and a concomitant decrease in the number of days they could survive caging and starvation (22 days). Apparently the hens during this period were able to adapt themselves to the stress of egg laying, but did not have sufficient energy reserve remaining, or the power to generate energy, to survive starvation as well as birds in midwinter and early spring. In June, initial weight declined further, and survival time also decreased, as egg-laying activities continued to make great energy demands upon the hens.

4. In several of the seasonal studies, the effect of such factors as wing molt, age, time of hatch and physical condition on the hen's ability to withstand applied stress were also considered. A difference was detected in the stress resistance of hens which began their postnuptial molt of primary flight feathers early and those which began their molt late. The "late molters" had the lowest survival, 11 days; within this group, the birds which had not yet begun to molt lived only an average of 10 days under stress.

In a further comparison of the two molt groups in September, the "early molters" had gained more since July and weighed more than the "late molters", but during applied stress they lost more weight.

Adult birds weighed more than the immature ones at the beginning of the experiment concerned with the influence of age on the hen's ability to withstand stress. Although the per cent of weight lost during the stress period was almost identical for both groups of birds, the adult birds showed a higher survival than did the immatures.

Results from the studies which compared the stress resistance of early- and late-hatched birds suggest that birds hatched earlier in the spring may be superior in their ability to withstand stress than those hatched later in the season.

Both groups of wild birds which were subjected to the stress regime had been undergoing the natural stress of a mild disease condition and/or undernourishment, and had a shorter survival time than did the game-farm controls. Thus a lowered physical condition apparently decreased the ability of the hen to resist the applied stress.

5. In order to measure the effects of caging alone as a stress and the effects of caging followed by starvation, a separate study was conducted in September 1950. Caging acted as a moderate stress, causing the birds to lose weight to the low level characteristic of the hens in summer. Only slight further loss occurred, suggesting that some adjustment mechanism apparently operated to prevent further decrease in weight after about a week. The failure to regain the weight lost, however, suggested that caging continued to be a mild stress, comparable to that caused by such natural factors as molting. The application of starvation to the caging stress caused a more rapid loss of weight in the same time interval than was shown by other groups of birds that had been subjected to a starvation treatment with no prior caging.

6. Several possibilities for the use of this information directly by management, as a technique in other research studies, and as a means for further interpreting population behavior were outlined.

## LITERATURE CITED


**Bennett, Logan J.**

1938. The blue-winged teal; its ecology and management. Collegiate Press, Inc., Ames, Iowa, 144 pp.

**Bennitt, Rudolf**

1951. Some aspects of Missouri quail and quail hunting 1938–1948. Tech. Bull. No. 2, Missouri Conservation Comm., 51 pp.

**Buss, Irven O.**

1946. Wisconsin pheasant populations. Pub. 326, A–46, Wisconsin Conservation Department, 184 pp.

**Buss, Irven O., Roland K. Meyer and Cyril Kabat**

1951. Wisconsin pheasant reproduction studies based on ovulated follicle technique. Journal of Wildlife Management 15 (1):32–46.

**Best, C. H. and N. B. Taylor**

1945. Physiological basis of medical practice. 4th Ed., Waverly Press Inc., Baltimore.

**Christian, John J.**

1950. The adreno-pituitary system and population cycles in mammals. Jour. Mammology 31(3):247–259.

**Dorney, Robert S.**

1955. Sex and age characteristics of a declining ruffed grouse population. Paper presented at the 17th Midwest Wildlife Conf., Lafayette, Indiana.

**Emlen, John T., Jr.**

1940. Sex and age ratios in survival of the California quail. Journal of Wildlife Management 4(1):92–99.

**Flakas, Kenneth G.**

1951. Pittman–Robertson Wildlife Pathology Study 24–R. Wis. Wildlife Research 10(1):183.

**Gerstell, Richard P.**

1942. The place of winter feeding in practical wildlife management. Research Bulletin No. 3, Pennsylvania Game Commission, 121 pp.

**Greeley, Frederick**

1953. The relationship of natural and artificial stresses to the function of the endocrine glands in ring-necked pheasants and domestic fowl. Ph.D. Thesis, University of Wisconsin, 173 pp.

**Kabat, Cyril, Donald R. Thompson and Frank M. Kozlik**

1950. Pheasant weights and wing molt in relation to reproduction with survival implications. Technical Wildlife Bulletin No. 2, Wisconsin Conservation Department, Madison, 26 pp.

Kabat, Cyril, Frank M. Kozlik, Donald R. Thompson and Frederic H. Wagner
1955. Evaluation of stocking breeder hen and immature cock pheasants on Wisconsin public hunting grounds. Technical Wildlife Bulletin No. 11, Game Management Division, Wisconsin Conservation Department, 58 pp.

Kirkpatrick, C. M.
1944. Body weights and organ measurements in relation to age and season in ring-necked pheasants. Anat. Rec. 89:175–194.

Kirsch, Leo
1951. Our winter storm losses. South Dakota Conservation Digest 18(4):2–3, 7, 12.

Kozlik, Frank M.
1949. Pheasant-quail management research project 9–R. Wis. Wildlife Research 8(1):51–64.

Leopold, Aldo, Theodore M. Sperry, William S. Feeney, and John O. Catenhusen
1943. Population turnover on a Wisconsin pheasant refuge. Journal of Wildlife Management 7(4):383–394.

Leopold, A. Starker
1945. Sex and age ratios among bobwhite quail in southern Missouri. Journal of Wildlife Management 9(1):30–34.

McCabe, Robert A.
1949. A ten-year study of a refuge population of ring-necked pheasants. Ph.D. Thesis, University of Wisconsin.

Miller, Wilford L.
1948. Pheasants killed by blizzard. North Dakota Outdoors, March 1948, pp. 4–6, 10.

Mosby, Henry S. and Charles O. Handley
1943. The wild turkey in Virginia: its status, life history and management. Commission of Game and Inland Fisheries, Richmond, 281 pp.

Selye, H.
1949. The general—adaptation—syndrome and the diseases of adaptation. *In* Textbook for Endocrinology. Montreal Acta Endocrinologica, Inc., pp. 837–867.

Stokes, Allen W.
1954. Population studies of the ring-necked pheasant on Pelee Island, Ontario. Wildlife Series No. 4, Ontario Department of Lands and Forests, 154 pp.

Thompson, Donald R.
1951. Pheasant-quail management research project 9–R. Wisconsin Wildlife Research 10(1):136–153.

Wilson, E. A.
1911. The weight of grouse. *In* The grouse in health and disease. Smith, Elder & Co., London, Vol. I: 130–146.