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HEASANT WEIGHTS AND NG MOLT IN RELATION TO REPRODUCTION WITH SURVIVAL IMPLICATIONS

by

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Pittman-Robertson Project 9-R

TECHNICAL WILDLIFE BULLETIN NUMBER 2

Game Management Division
WISCONSIN CONSERVATION DEPARTMENT
MADISON 2, WISCONSIN
1950

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ACKNOWLEDGMENTS

This work was supported in part by a grant-in-aid from the Wisconsin Alumni Research Foundation and by Wisconsin Pittman-Robertson pheasant research project 9-R. The authors acknowledge the cooperation of the Wisconsin Conservation Department which furnished pheasants, feed, and pens for experiments, Bert A. Barger for special cooperation in the maintenance and selection of pheasants, Dr. James Torrie for statistical advice, Drs. R. K. Meyer and R. A. McCabe for critical reading of the manuscript.

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CHANGES IN PHEASANT WEIGHTS AND WING MOLT IN RELATION TO REPRODUCTION WITH SURVIVAL IMPLICATIONS

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INTRODUCTION

Does the occurrence of inclement weather or other unfavorable conditions during the breeding season, especially at hatching time, detrimentally affect the physical condition of adult upland game bird hens? The conditions referred to are those commonly believed to cause hens to have late hatches or even to result in a failure of hens to bring off broods. The consequences of abnormally late hatching seasons in pheasants are production of a small crop of young and relatively immature birds for the hunting season (Nelson, 1948), and a decline in the total fall population.

Many studies have been published on the factors that affect reproduction and the survival of young birds, but what remains unknown is whether a delay in any one stage of the breeding phenomenon directly affects the physical condition and survival rate of the hen, particularly hens which have attempted repeatedly to hatch and raise broods.

If the factors that cause late hatching and a resultant small crop of young birds also tend indirectly to increase the mortality rate of adult birds, fall populations would be even more reduced in such years than has previously been estimated. The importance of knowing more about the direct effect of these factors is apparent when consideration is given to the years and areas in which the percent of adults in a given upland game bird population is relatively high. For example, in 1945 age-ratio checks on hunting season pheasant kills in South Dakota (Nelson, 1948), approximately 50 percent of the birds examined were adults. McCabe (1949) reported on the ages of pheasants trapped at the University of Wisconsin Arboretum during the winters of 1943-49 and found that the adult component ranged from 43 to 59 percent.

Although this report deals directly with data on adult hen pheasants, it is recognized that the reproductive capacity of the late-hatched young birds might also be detrimentally affected. This is illustrated by observations on domestic chickens that have shown that early-hatched pullets tend to start laying eggs earlier than those hatched at later dates. Byerley and Knox (1946) reporting on this relationship found that late-hatched birds (week of April 18) laid their first egg an average of three weeks later than did early-hatched birds (week of March 21). They also found that the length of day occurring at the time of the laying of the first egg tended to modify the late-hatching effect on the date of the first ovulation. A parallel condition was described for mammals by Allen (1942) except that the factors involved in delaying litter birth was a nutritional one. Female fox squirrels which were born late in the season had just one litter (also late) in their first breeding season, whereas many of those born in spring produced two litters, one in spring and one in summer. The effect of delayed birth in these two species on their respective populations are apparent.

From the time pheasant chicks are first hatched to the date of their death, they go through a series of such natural physiological and morphological processes as growth and molt (Kirkpatrick, 1944). It is hypothecated that a delay or disruption of these processes, such as that caused by late hatching, would tend to throw their normal development out of phase with certain seasonal elements such as temperature, length of day, and the availability of different types of foods. It is difficult to measure the effect of adverse environment on physiological changes within the birds, since in most cases this would require autopsy or biological assay. However, considerable knowledge of the effect that late hatching has on the physiology and indirectly on the survival of adult hens may be obtained by studying the physical characteristics of weight changes and molt progress in both pen-reared and wild pheasants, and then correlating these data with the reproduction phenomena.

This report first describes the relationship of molt and seasonal weight changes in adult pheasants and follows this with a discussion on the possible effect that delayed reproduction has on the survival rate of adult hens.

OBJECTIVES

The primary objective of this study was to obtain information on the effect of late hatching season characteristics on adult hens that may affect survival. This was to be accomplished by determining (1) during what stage of the breeding season the fat reserves accumulated in February, March, and April by adult hens are lost (Leopold, Sperry, Feeney, and Catenhusen, 1943; Kirkpatrick, 1944), and whether there is any correlation between the number of eggs laid and the amount of weight lost in any one year; (2) the date at which adult hens begin to recover the weight lost during the breeding season, and whether this date is correlated with the onset of the post-nuptial primary molt; and (3) whether the date on which adult hens begin their post-nuptial molt and post-breeding season weight gain bears a relation to the dates on which these hens hatch their broods.

MATERIALS AND METHODS

To obtain data on the molt and weight changes which occur during various periods, pheasants were penned at the Wisconsin state experimental game and fur farm where they were weighed and examined for their post-nuptial molt progress at intervals throughout the year. An opportunity to get information on the relationship between the post-nuptial primary molt of wild adult hens and their breeding cycle occurred during the investigation of certain crop damage problems and summer trapping studies wherein hens and one or more of their chicks were obtained for examination.

The required data (objective 1) on spring and early summer weight changes were obtained from an experiment involving 75 adult hen pheasants that were to be used in an endocrine study by Frederick Greeley of the University of Wisconsin. These hens were weighed first at the time they were transferred in March from holding fields four acres in size to breeding pens 12 feet square. At this time the hens were confined separately, and one cock was penned with each hen. The 75 hens were divided into three groups of 25 each according to the number of eggs laid up to the time at which they were autopsied. Group I consisted of hens collected after they had laid their first egg; Group II was allowed to lay 30-45 eggs before collecting; and Group III was examined after ceasing to lay some time in July. Weights were again taken at the time of autopsy.

To correlate post-breeding season weight changes (objective 2) with the post-nuptial primary molt, three groups of adult hens (A, B, and C) were weighed at specific intervals during a period beginning July 17, 1947, and extending to March 1948. Two of the groups, A and B, consisting of 18 hens each, were selected at random from the game farm breeding pens (12 feet square), where they had been laying continuously from mid-April to June 20. While in the breeding pens, the eggs laid by these hens were removed daily. On June 20 they were transferred to rearing pens (100' by 25'). All of these hens continued to lay in the rearing pens, and some even incubated clutches. They were again transferred on July 17 to two other rearing pens, 100' by 50', where they remained until March. Group A was weighed, and its molt recorded at two-week intervals, while similar data were obtained on Group B, but at two-month intervals. The purpose of segregating the groups into birds examined at different intervals was to measure the effect of handling on weight and molt changes.

For additional information on post-breeding season weight and molt changes, the third group (C), consisting of seven hens, was penned with one cock each in a rearing pen 100' x 35' on March 19, 1947, and each hen was weighed at this time. They were weighed again on July 17 and thereafter at two-week intervals until March 18, 1948. It was expected that this group would show a molt pattern and weight change more typical of the wild pheasant than did Groups A and B, that is if there actually was such a difference, because the hens were penned under conditions that simulated wild pheasant habitat. All of the eggs laid by the group C hens were left in the pen. It was expected that these environmental conditions would tend to induce more natural breeding. Six of these hens in Group C began incubating clutches in June, five of which hatched before early July.

Data on the relation of the molt of hen pheasants and their broods (objective 3) were obtained from the collection of wild pheasants from areas reporting crop damage in the summer of 1946 and 1947, during which time 25 adult hens were collected. Additional data were obtained in August 1948 and 1949, when five hens and their broods were live-trapped.

RESULTS AND DISCUSSION

SPRING AND EARLY SUMMER WEIGHT CHANGES

The weight changes occurring in Groups I, II, and III are shown in Table I, and they indicate that weight loss probably was gradual and that most of the breeding season loss occurred before mid-summer. The mean difference between weight loss of Groups I and II is statistically significant. Although the mean difference between Groups II and III was relatively large, the difference was not statistically significant; this might be explained by the great amount of individual variation in the weight change within each group of birds but which averaged much more (70 to 297 grams lost) in Group III. However, the mean differences of all three groups when tested collectively by an analysis of variance were found to be highly significant (an F value of 4.93 was obtained by using the method described by Snedecor, 1946).

It is apparent that the data on weight losses in Groups I, II, and III (Table 1) do not represent truly randomized samples, since different birds compose each of the groups. An ideal test would be one in which the same group of birds was weighed at each one of the stages of egg-laying listed above. Despite this minor weakness in the experimental design, the results strongly indicate that there is a high correlation between weight loss and egg laying.

Kirkpatrick (1944) weighed a group of hens at five-week intervals during a period of 680 days, and his hens showed only a slight weight loss from April to June with the greatest decrease occurring in late July and August. On the basis of these observations, he suggested that hot weather and molt might have been the predisposing factors in this weight loss. Kirkpatrick's report, however, did not present detailed information on egg laying. Both Kirkpatrick and the authors reporting herein agree that by early August, adult hen pheasant weights are at a minimum.

WEIGHT CHANGES FROM JULY 1947 TO MARCH 1948

Although Group C was penned in simulated wild habitat with a minimum of human interference and Group A in relatively small crowded pens with the eggs laid removed daily, the weight changes for the same time intervals were very similar. Therefore it appeared justifiable to combine the results from these two groups and analyze them in the aggregate. The variation in weight change for the birds in Groups A and C is shown in Table 2.

The data demonstrate the extreme variability which occurs in pheasant weights. The incipient stage of the weight increase trend for most of the birds began about September 18, 1947, and was climaxed on November 18, 1947. From November, 1947, to February 3, 1948, the average weights remained at the same level, but during this same period individual hen weights fluctuated between weighing dates. It was impossible to attribute this variability between individuals within any one group to any one cause. Some heavy birds of 950-1,050 grams made constant but relatively small weight gains throughout the period of July 17, 1947 to March 18, 1948, while others gained heavily. The same was true of birds which were relatively light at the time they were first weighed.

The trend in weight change in grams for all of the hens which had been weighed at two-week intervals is shown as a three-period moving average in Fig. 1. The weight change was determined by subtracting the July 17 weight from that obtained on subsequent dates. A few birds were missed at each weighing, which accounts for a variation of about two hens at each date. The weight trend for the period shown was similar to that found by Kirkpatrick (1944).

Because of the variability shown by individual birds (Table 2) at each weight period, it was necessary to test the trend shown in Fig. 1 for statistical significance. Snedecor's (1946) "F" test was used to analyze the variance. The results of the analysis are shown in Table 3.

The analysis indicate that there was a continual weight gain from July 18 to November 18, 1947, and also that there was no significant difference between the averages shown for the winter period of December 3, 1947 to February 3, 1948.

Groups A and B were weighed at two-week and two-month intervals, respectively. The weight change between comparable periods for both of these groups is shown in Table 4. The difference between the average weight changes for the two groups are not statistically significant, which indicates that handling of the birds at intervals as frequently as two weeks did not measurably affect the weight gain.

MOLT AND ITS ETIOLOGY

During the summers of 1946-49 the primary molt stage for 30 adult hen pheasants and one or more of the chicks in each hen's brood was recorded on various study areas in Wisconsin. Previously published reports on adult pheasant primary molt was limited to data on three wild hens (Buss 1946). The results of the examination of the collections in this study are shown in Table 5. For each hen collected an age estimate of her brood was made in one of two different ways. If chicks were collected simultaneously with the hen (identified by "C" in column 3), the age of the brood was estimated from the stage of the molt in the primary wing feathers of the chick, according to the method reported by Buss (1946). In other cases where no chicks were collected, the age of the hen's brood was determined from the size and plumage characteristics; here a molt stage was assigned which corresponded to the sight age estimate. The post-nuptial molt stage in the wing of the adult hens when compared with that of the post-juvenile molt stage in the wing of one of her chicks showed an extremely good correlation.

There was only one case, No. 56, in which the primary molt of the hen differed from the molt of her chicks by more than one primary. Although there were five cases in which the chicks deviated from the parent hens by one primary, in most instances the difference could be accounted for by a primary which was loose but which had not as yet dropped out. These results indicate that the primary molt stage of adult hens are closely associated with the date of hatching of her brood. It is noteworthy that this correlation occurs despite the great variation in the date that the hens and their broods were examined. Thus hen Number 7 (Table 5) was found incubating a clutch of eggs of September 9, 1947; she had not started her wing molt. Examination of Table 5 also shows that hens with 10-week old chicks had all dropped approximately seven primaries despite the fact that they were collected on different dates.

Many investigators have conducted experiments designed to determine the relationships between molt and environmental conditions such as day length, temperature and diet. Several authors have reported on studies in which they had induced different species of birds to commence their molt by increasing day length through artificial lighting. Lesher and Kendeigh (1941), in summarizing early experiments along these lines, point out that the literature is suggestive of various controlling influences over molt, but that many of the results of experiments are confusing and often contradictory. Their remarks indicate that the responses to different treatments may vary according to the species with which the experiment is being conducted. For example, Burger (1941) found that the molt of the male starling under laboratory conditions occurred independently of the changes in length of day, while Host (1942) was able to induce a male willow ptarmigan in February to change from a spring plumage to a complete winter plumage within a period of two months by artificially decreasing daylight to seven hours.

The effect of environmental influence on molt of wild live-trapped juvenile and adult quail and mourning doves was shown by the finding of cases of arrested molt in December (Thompson and Kabat, 1950; and Thompson in press). The arrested molt occurred in quail which hatched at later than average dates and in a winter which was characterized by the early arrival of snow and abnormally low temperatures.

Despite the varied responses in molt changes to natural day length and artificial manipulations thereof, it is apparent that photoperiodism is one of the overall operating factors that controls molting in birds. The magnitude of the response, however, is affected by heritability, species variation, and environmental influences (Asmundson, Lorenz and Moses, 1946).

Van der Mulen (1939) and Greenwood (1936) in attempting to explain the physiological implications in the molting process state that a hyperthyroid condition in the domestic chicken may be the cause of molt. The former suggests that lowered reproductive activity may or may not be in certain birds an essential condition for the onset of molt. The data presented in Table 5 is in agreement with Van der Mulen's suggestion, since the results of these studies show that the molt of the hen did not begin until after she had ceased laying and had completed incubating her clutch.

The endocrine relationship of molt and egg laying is indicated in the affect of thyroid activity on both these phenomena. While a hyperthyroid condition may in part cause molt, a hypothyroid condition appears to be involved in the reduction of egg laying in summer in the domestic chicken according to Turner, Kempster, Hall and Reineke (1945). These authors fed thyroprotein a substance which contains thyroxine to domestic chickens and thereby increased the blood level according to the intake but which simultaneously inhibited their own output of thyroid hormones. The treated hens continued to lay eggs during the summer at a rate comparable to winter levels, whereas untreated groups fell off in their egg production after May 7. The authors concluded that the seasonal cycle of egg production is due in part to a reduced secretion of thyroxine during the summer months.

Since thyroid activity begins to increase in both young and adult chickens (Reineke and Turner, 1938; and Galpin, 1938 respectively) in late summer, it appears that this endocrine gland following a decrease in its activity first affects egg laying and then when a higher level of hormone is again being produced it stimulates molting.

The molt stage of each of the hens used in the weight study were recorded at the time the hens were handled for weighing. The data are presented in Table 6. Since the primary purpose of this part of the study was to determine whether there was a correlation between weight changes and the replacement schedule of primary feathers during the post-nuptial molt, the data obtained does not precisely show the specific period of time required for individual primaries to be replaced. These data do, however, demonstrate that the primary wing feathers were molted at a relatively constant rate. The "Weeks After Completion" column of Table 6, shows the number of birds which had completed their molt on and after November 3, 1947, and also the number of weeks elapsing after completion of the wing molt by individual birds for the period of December 18, 1947, to January 18, 1948. For example, on November 18, ten hens had just completed their primary molt whereas on December 3, these ten hens are recorded as having completed their molt two weeks previously.

The data on the wild bird collection strongly suggest that the adult hen does not start the primary molt until after her brood is hatched. However, some of the penned hens examined on July 18, 1947 (Table 6), were molting while still laying. Possibly the commencement of molt while laying was still in progress was induced either by the environmental changes which occurred during the breeding season of these birds or the egg production behavior. Eighteen of the birds (Group A) for which the molt stage is listed in Table 6 had been laying steadily in breeding pens 12' x 12' from mid-April to mid-June. While in these pens the eggs produced were taken from the hens daily. The ratio of cocks to hens in these breeding pens was 1:5.

On June 20, 1947, the 18 hens were transferred along with other birds to rearing pens 100' x 25', where the cock-hen ratio was approximately 1:1 but with an average of 34 birds to each pen. Some of the transferred hens ceased laying immediately, whereas others continued to lay but at a reduced rate. The eggs produced were left in the rearing pens and many of the hens began incubating clutches. The transfer of the hens from one habitat to another might be one of the basic factors acting to disrupt the normal sequence of molt, or it could have been the cessation or decrease of the laying rate that affected the plumage change. The other hens for which data are also listed in Table 6 (Group C) remained in rearing pens simulating the natural habitat from March 1947 to March 1948, and the dates of their wing molt were similar to that presented for the wild birds.

In order to determine whether frequent handling affects molt rate, Groups A and B were compared (Table 7). The length of time required for the completion of molt of individuals, as well as for the groups, is almost identical, and hence it appears that bi-weekly handling had no more effect on the molt rate and weight cycle than bi-monthly examination.

Some information was obtained on the molt rate of adult cocks. The wing molts of 16 cocks which were penned with Groups A and B were examined on July 19, 1947. The results are shown in Table 8. The wing molt stage of the cocks is almost one month in advance of the hens in Groups A and B. Additional data on the sex differential molt pattern were obtained when 25 adult cocks and 55 adult hens enclosed in rearing pens were examined for the stage of primary molt in June 1948. Although all of these cocks had started to replace primaries, only one of the hens had started to molt. It appears that the sex-differential molt schedule is in phase with gonad development, because testicular development which begins in February is also one month in advance of the ovaries which show no increase in size until March (Kirkpatrick 1944).

CORRELATION OF WEIGHT, EGG PRODUCTION AND MOLT CHANGES

Comparison of the data on weight changes (Table 2 and Fig. 1) and molt progress (Table 6 and Fig. 2) shows that the average dates on which the early winter weight-increase trend plateaus and the post-nuptial wing molt is complete are almost identical. This raises several questions. Is the date on which the adult birds regain normal winter weights directly influenced by the date on which molt begins, or by environmental changes such as reduction of daylight, decreased temperature and food availability? Are post breeding season weight gains and post-nuptial molt which is linked with reproduction interrelated?

Some investigators have found that in certain species of birds not only did change in photoperiod through artificial lighting result in the commencement of molting, but it also influenced egg production. For example, Host (1942) was able to bring on both egg laying and molting in winter in the willow ptarmigan by artificial lighting. However, Riley, Gardner and Byerley (1943) found that artificial lighting increased egg production in the domestic chicken, but it did not affect their molt rate; but, the chickens used in their experiment had started their wing molt at the time the experiment began. These authors concluded that in the domestic hen, once wing molt commences, an increase in reproductive activity will not affect the rate of wing molt.

The commencement of molt while still laying, as observed in artifically propagated pheasants in this study, supports the belief of Van der Mulen (1939) that molting and laying cycles are two separate phenomena and are controlled by different mechanisms, but that there is a secondary interaction between the two.

In order to show the mean trends and the relationship of post-nuptial primary molt and breeding season weight increases the data used in Tables 2 and 6 were computed on a moving average basis and plotted in Figs. 1 and 2. The results in part (Fig. 1) show a curvilinear regression of average weight changes on two-week time intervals. This curve when considered alone suggests that the time when the adult hens begin to regain the weight lost (and the rate of gain) closely related to progressive changes in the season of the year, thus implying that day-length and weather may affect the physiology of the bird and this effect may be manifested in weight and plumage changes. If there were no other factors involved, this simple explanation would suffice to describe the weight change-seasonal relationship.

However, the complexity of this relationship is added to by the results obtained when the average stage of the progress of the post-nuptial primary molt for these birds is plotted on the same graph (Fig. 1) with the weight changes. Each number in the histogram depicts the average number of primaries molted on the date each of the weights were obtained. The relationship of changes in molt, weight, and seasons are shown from the time the first primary was dropped up to the time the tenth primary (most distal) had completed its growth.

The development of the tenth primary was tabulated as having four stages (Table 6). Each stage represents two inches of growth, with the third stage terminating at 4-6 inches of length and the fourth stage being that at which the feather had completed its growth. In Fig. 1 and Table 6, the development of the tenth primary is also expressed in terms of additional primaries being replaced. The reasoning here is that six weeks were required to complete the growth of the average tenth primary, and during the six-week period prior to the time the tenth primary began its development, a total of 4 primaries, the sixth through the ninth, were replaced.

The above data suggest that the regressions of molt and weight on season are independent but that there is a secondary interaction between weight change and molt progress. This phenomenon may be similar to the indicated relationship between egg laying, thyroid activity and molting discussed earlier in this report. The possibility of an independent relationship and a secondary inter action between the two is further suggested by plotting the average whole weights of each of the hens used in constructing Fig. 1 at each of the different stages of their molt. Here too a high correlation is indicated. The curve delineated in Fig. 2 shows more irregularity than that in Fig. 1, but this may be explained by the varying number of weights obtained at each molt stage. This variation occurred because some of the birds (Table 6) had completed their molt at the time they were first examined. Also since the weighings were made only once during each two-week interval, many of the hens had shed more than one primary between examinations. This was particularly true in the cases of birds having molted their first, second and third primaries. The reverse occurred in the final stages of the growth of the tenth primary.

It would be impossible to determine from the data on penned birds even with complicated statistical analysis, whether there is a higher correlation between the changes in weight and season, molt and season, or molt and weight. The characteristics of this relationship are further complicated by the pen conditions and treatment involved in the handling of most of the game farm hens. Had it been possible to obtain repeated weights on the wild birds (Table 5) during the various phases of their breeding season, some of these variables might have been clarified.

Considering the data obtained on the penned birds alone, it is apparent that weight loss and gain are positively correlated with reproduction in adult hen pheasants. The implication here is that the adult hen does not start to regain the breeding season weight loss or begin the post-nuptial molt until after she has ceased laying or at least until after the rate of laying has measureably decreased. This interpretation is supported by the data obtained on the wild birds (Table 5) which show that the post-nuptial molt in 30 hens did not begin until after the broods were hatched. Therefore, on the basis of the data reported herein on game farm and wild birds, it is probable that the time when adult pheasants attain their early winter peak weights and complete the post-nuptial molt is at least indirectly related to the time when their young are hatched.

REPRODUCTION DELAYS THE MOLT SCHEDULE AND WEIGHT CHANGES

Whatever the basic cause is that brings on molt and the regaining of the weight lost during the breeding season, it appears to be linked with the time the adult hen becomes broody, incubates and hatches her clutch. Hence the occurrence of adverse weather or other factors which delay reproduction will also set back the date of the post-nuptial molt and the post-breeding season weight recovery. It is possible then, that the survival of adult hens which are behind in physical development, when fall and winter conditions prevail, could be handicapped accordingly. The exact way in which delayed reproduction could affect the survival of adult hens or their subsequent reproductive efforts is unknown, but probably it would be an increased suspectibility to mortality factors of all types that is involved. Some findings in domestic chickens might shed light on this subject.

The relationship of broodiness to survival is indicated in the experiments conducted by Byerley and Knox (1942) to determine the mortality rate of two groups of hens: (1) those which became broody prior to July 1, and (2) those that did not become broody at all. These authors found that the mortality rates as affected by all causes during the first four months following July 1 was 9.1 per cent for the hens that became broody before July 1 (Group 1), and 18.8 per cent for group (2). The difference in the mortality rate was statistically significant. While the results of this study on domestic chickens may not be directly applicable to pheasants, implications are important, and they are more fully elaborated in the following paragraphs.

One of the breeding practices in domestic chicken management is to select hens as brood stock that are heavy producers and which lay their eggs almost without cessation throughout the entire summer. Generally hens which commence molting late in summer, continue to lay eggs during molting. Eventually this management practice would result in flocks of non-broody birds. Elimination of genetic broodiness may reduce the capacity of the pituitary to produce prolactin (Byerley and Burrows, 1936), and raise the threshold of the genetically non-broody bird to prolactin (Riddle, Bates, and Lahr, 1935). Prolactin is a hormone required to produce broodiness. Ovulation studies by Buss, Meyer, and Kabat (pending publication) indicate that the annual average dates on which pheasants begin to lay their eggs in the wild or in open pens is relatively constant despite individual hen variation and the affect of weather and other environmental factors. On the other hand the date when most broods are hatched varies between different wild populations and also penned individuals. Apparently some factor or factors other than breaking up of nests by predators delay the date of the onset of broodiness in some birds, thus resulting in a prolongation of the laying period and the production of many eggs.

One such delaying factor is density, the effect of which was observed by Kozlik and Kabat (1950) in two successive years, 1948 and 1949, on pheasants confined in four pens each 100 feet long and 75 feet wide. Five hens and one cock were confined in two of the pens and 15 hens with three cocks in the other two. The average number of eggs laid was greater (40 compared to 27) and the average date on which incubation began was later (July 2 compared to June 10) in the pen containing 15 hens and three cocks.

If the laying of many eggs by pheasants affects the capacity of the pituitary to produce prolactin, or the response to this hormone is the same as was reported for domestic fowl, some hens may not become broody. This theory might explain the finding of a high percentage of broodless hens at the University of Wisconsin arboretum in 1947-49, while at the University Bay area, just one mile distant, only a relatively small number of hens were found without broods. The average hatching date at the arboretum area during this same period was two to three weeks later than at the University Bay (Kabat, 1949).

When the early efforts to hatch young are disrupted in species of birds having the inherent characteristic of renesting, or their reproduction is delayed for other causes, a relatively large number of eggs will be produced before the hen ceases laying. The detrimental effect that increased egg production may have on the progeny of such hens is shown in studies on the domestic chicken. According to Hayes (1949) one consequence of the laying of relatively large number of eggs by chickens is that "the viability in the high-producing families is lower between hatching and eight weeks from eight weeks to six months than in low-producing families." Hayes hypotecates that "egg production in female animals is one measure of metabolic rate. Life span is generally believed to depend on the energy metabolized." He also points out that although no experimental data are available regarding the relation between the numbers of eggs laid and life span in chickens, Gowen and Johnson (1946) found that the longevity of heavy egg-producing females of the species Drosophila melanogaster were reduced.

One other concept may be added to this discussion: Allen, Hisaw, and Gardner (1939) reported the increase of the incidence of certain types of mammalian neoplasms when the female hormone was greatly increased. Marine and Rosen (1941) suggest that the female hormone might render chickens more susceptible to the development of the avian-leucosis complex. This could happen in adult pheasants and many other species of birds, when as was suggested above, some factor caused the hens to lay more eggs than normally, thereby both prolonging the period during which the female hormone was produced and also increasing the total output. This could then be followed by a greater incidence of the avian-leucosis complex and result in an increased mortality rate.

Finally, this report can be concluded by comparing the effects of delayed reproduction on the physical well-being of hen pheasants to the "adaptation diseases" that result from nonspecific reactions of the body to long-continued exposure to stress (Selye 1946). Prolonged laying in itself constitutes a stress which is added to by setting back the date when the hen molts and regains the breeding season weight loss. If the molt and weight gain are not complete by the time winter weather arrives with low temperatures, decreased daylight and food availability, the energy required to maintain body temperatures and to complete physical development is greater than would be the case if these processes had occurred earlier in the season. Since the endocrine glands involved in egg laying, molting, and weight changes also play leading roles in the building of resistance to stresses, it seems very logical to assume that the survival of game birds would be affected in the magnitude of the intensity and the length of exposure to stress.

Thus it is highly probable that the factors which cause delayed reproduction and manifest their effects in brood hatching dates and broodless hens in any given pheasant population, would eventually produce a much higher rate of mortality among adults and possibly in the progeny of these birds than would naturally be expected. The dire consequence of such a circumstance is apparent.

SUMMARY

Adult hen pheasants lose weight during the egg-laying season. By July 17 most adult hens have reached their lowest summer weight. The wing molt of the adult hen begins at the time the hen's summer weight is at a minimum. The hens show a steady weight increase which begins in midsummer and reaches a peak in early December of the same year. The weight curve of adult hen pheasants shows a plateau extending from early December to February.

The post-nuptial wing molt is completed at approximately the same time the hens reach their maximum early winter weight. Wing molts of adult cocks begin one month in advance of the hen. This is in phase with testicular development which begins in February, while ovaries increase in size in March.

The factors causing molt and its relation to reproduction are discussed. Rates of development of the primary wing feathers of wild adult hens were found to be comparable to that of the hen's

brood, which indicates that the onset of the post-nuptial molt can be correlated directly with the date the brood is hatched. Wing molt and weight change are two possible characteristics which can be used to deduce facts about the reproductive history of adult hen pheasants.

Prolonged egg laying due to nest destruction or other factors inhibiting the development of broodiness constitutes an abnormal stress that may result in an increased susceptibility to mortality causes of all types. Thus hens bringing off late broods, or not becoming broody, may have a higher incidence of such diseases as the avian-leucosis complex. This appears to be the case in domestic chickens.

Delay of the hatching date 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.

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Table 1

THE AVERAGE CHANGE IN ADULT HEN PHEASANTS WEIGHED DURING THE LAYING SEASON

GROUP	NUMBER OF HENS	NUMBER OF EGGS LAID	PERIOD OF WEIGHT CHANGE	AVERAGE WEIGHT CHANGE (GRAMS)
I	22	1	3/19-4/22	25 gain
II	20	30-45	3/19-6/10	127 loss
III*	16	plus 45	3/19-7/25	173 loss

*All of the hens in this group laid more than 45 eggs, and were collected only after they had ceased laying.

Table 2

FREQUENCY DISTRIBUTION OF WEIGHT GAINS, ADULT HEN PHEASANTS, FOR GROUPS A AND C COMBINED[1]

WEIGHT CHANGE INTERVAL (GRAMS)	8/3	8/18	9/3	9/18	10/3	10/18	11/3	11/18	12/3	12/18	1/3	1/18	2/3	2/18	3/3	3/18
250-299									1	1	1			1		4
200-249								2	1	2	2	1	2	4		2
150-199						3	3	5	6	6	5	3	7	7		2
100-149				6	7	5	8	9	5	5	6	9	6	2		1
50-99		3	4	4	7	11	7	4	4	2	3	3	3	2		1
0-49	11	9	12	9	5	4	1	1	2	3	1	2	1	3		1
(-49)-(-1)	7	7	5	2	2											
(-99)-(-50)	4	2	1													
Average	-5	2	17	54	73	91	101	138	129	142	146	127	139	149		189

[1]The change in weights of adult hen pheasants between July 17, 1947, and March 18, 1948.

Table 3

THE AVERAGE WEIGHT CHANGE IN 25 ADULT HEN PHEASANTS FROM MARCH 18, 1949 TO THE DATES SHOWN IN COLUMN 1

PERIODS COMPARED	AVERAGE WEIGHT CHANGE FOR THE PERIODS COMPARED (GRAMS)	F
8/3/47 and 9/18/47	5 loss and 54 gain	26.0**
11/3/47 and 11/18/47	101 gain and 138 gain	5.90*
12/3/47 and 2/3/48	129 gain and 139 gain	0.32

**Highly significant

*Significant

Table 4

COMPARISON OF THE CHANGES IN ADULT HEN PHEASANTS WEIGHED AT TWO-WEEK AND TWO-MONTH INTERVALS

GROUP	AVERAGE WEIGHT INCREASE 1947 (GRAMS)	
	7/18 - 9/18	7/18 - 11/18
A (Two Weeks)	38	152
B (Two Months)	43	167

Table 5

CORRELATION OF WING MOLT STAGES IN ADULT HENS AND THEIR BROODS

COLLECTION DATE	HEN NO.	AGE OF BROOD IN WEEKS*	PRIMARY MOLT STAGE OF BROOD	PRIMARY MOLT STAGE OF ADULT HEN**
9/9/47	7	Incubating	--	0
6/29/46	4	5	2	2
8/16/47	56	5 C	2	4
7/13/46	10	6 C	3	2 (3 loose)
7/13/46	12	6	3	3
8/5/47	N	6 C	3	4
7/26/49	37140K	7 C	4	4
7/13/46	14	7-8	4-5	4
7/26/46	15	8 C	5	4
8/11/48	31255	8 C	5	4
7/26/49	37126K	8-9 C	5-6	6
9/9/47	3	8-9 C	6	6
8/16/47	54	9 C	6	6
8/24/48	31392	9 C	6	6
9/11/47	PM	9½C	7	6
9/12/47	9	9-10 C	6	8
8/6/46	20	10	7	6
8/6/46	21	10	7	7
8/13/46	27	10	7	7
8/16/47	28	10	7	7
8/21/46	29	10	7	7
8/27/46	30	10	7	7
8/6/46	18	10-11	7	7
8/29/46	32	10-11 C	7-8	7
9/11/47	PM	10½	7	7
8/23/48	32446	10½ C	3-7, 4-8	7
9/12/47	8	11 C	8	7
9/12/47	PM	12½	8	7
9/13/47	13	12	8	8
8/29/46	31	13 C	9	8 (9 loose)

*"C" following brood age indicates that the molt stage, and hence the age of the brood, was determined by collecting one or more of the chicks and examining it. In the other cases the ages of the chicks were estimated, and a molt stage assigned which corresponds to that age of the chick.

**The molt stage of all hens was determined by examining after collecting. Hen 32446 was trapped with her brood of seven chicks, three of which had shed seven and four had shed eight juvenile primaries each.

POST-NUPTIAL MOLT OF THE PRIMARIES

	Stage of Primary Molt									Regrowth of 10			Weeks After Completion					
DATE	1	2	3	4	5	6	7	8	9	0-2"	2-4"	4-6"	0	2	4	6	8	AVERAGE[1]
7/18	8	5	5	2	1	1												2.4
8/3			5	6	7	3												4.4
8/18				3	6	10	3											5.6
9/3					1	4	9	9										7.1
9/18							3	9	9	2								8.4
10/3								2	8	7	5							9.7
10/18									2	1	9	11						10 + 1.3
11/3									1	1	5	11	2					10 + 1.6
11/18											2	7	10	1				10 + 2.5
12/3												1	6	10	3			10 + 3.7
12/18													4	7	10	2		
1/3														1	7	9	2	
1/18															2	6	12	

[1]The average number of primaries molted at the time of each examination for the dates shown was computed by assigning units to "1" to each stage of molt. In order to compute the average molt rate for the stage during the "regrowth" of the 10th primary, it was necessary to use the intervals of 11 and 12 for the 2-4" and 4-6" stages respectively. The average molt rate after the 9th primary was dropped is expressed as the additional primaries that would have been shed if a pheasant had more than 10 primaries.

Table 7

COMPARISON OF WING MOLT PROGRESS FOR HEN PHEASANTS IN GROUPS A AND B

DATE	EXAMINATION INTERVAL	STAGE OF PRIMARY MOLT 0	1	2	3	4	5	6	7	8	9	10	COMPL.	TOTAL BIRDS
7/18	2 wk.	2	8	5	5	2	1							23
	2 mo.		3	7	4	3	1							18
9/18	2 wk.								3	9	9	2		23
	2 mo.									4	13	1		18
11/18	2 wk.											9	11	20
	2 mo.											4	14	18

Table 8

THE POST-NUPTIAL MOLT STAGE OF 16 ADULT COCKS (PENNED WITH GROUPS A AND B HENS) ON JULY 19, 1947

NUMBER OF COCKS	NUMBER OF PRIMARIES DROPPED
4	6
9	7
2	8
1	9

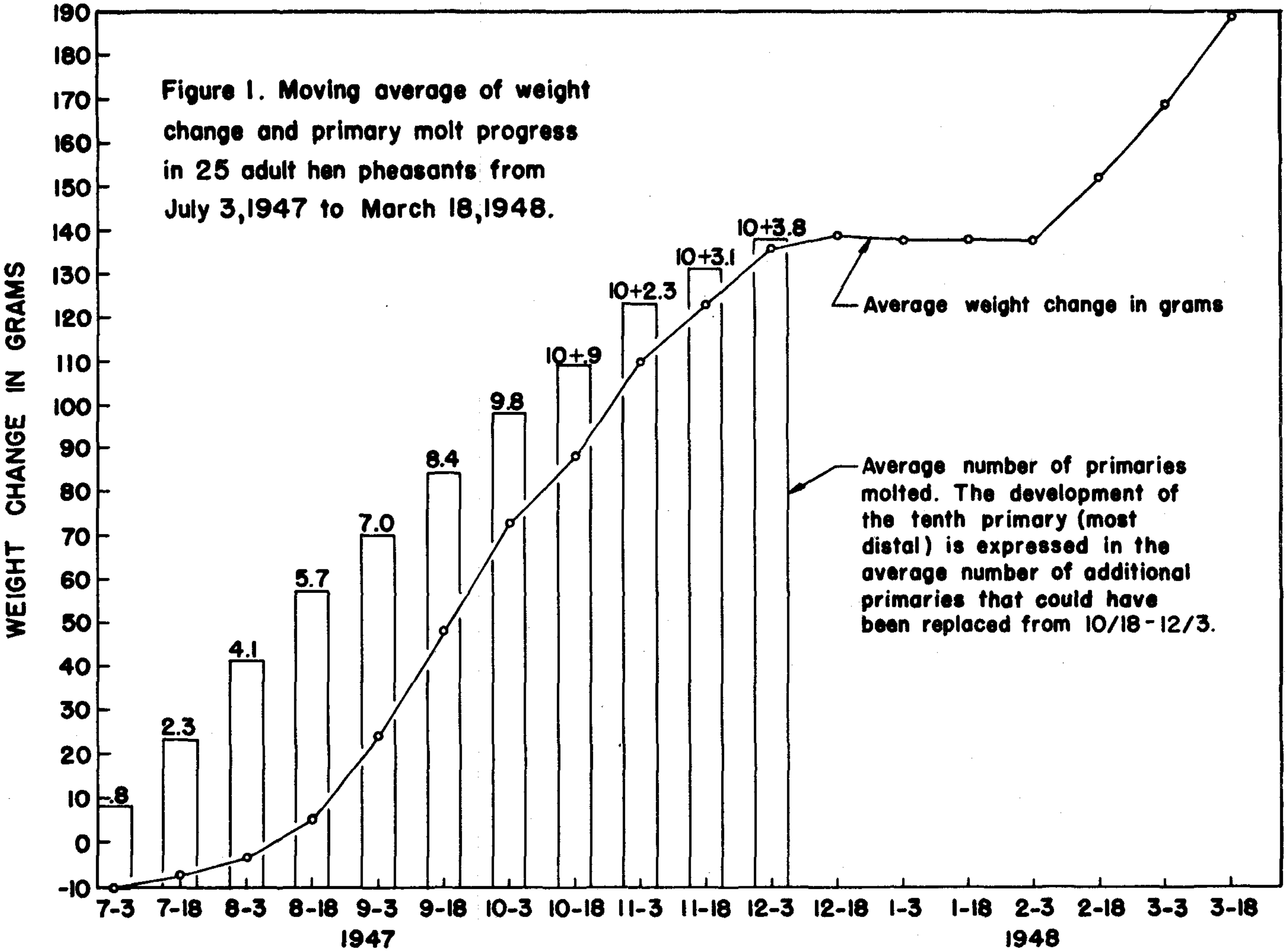

Figure 1. Moving average of weight change and primary molt progress in 25 adult hen pheasants from July 3, 1947 to March 18, 1948.

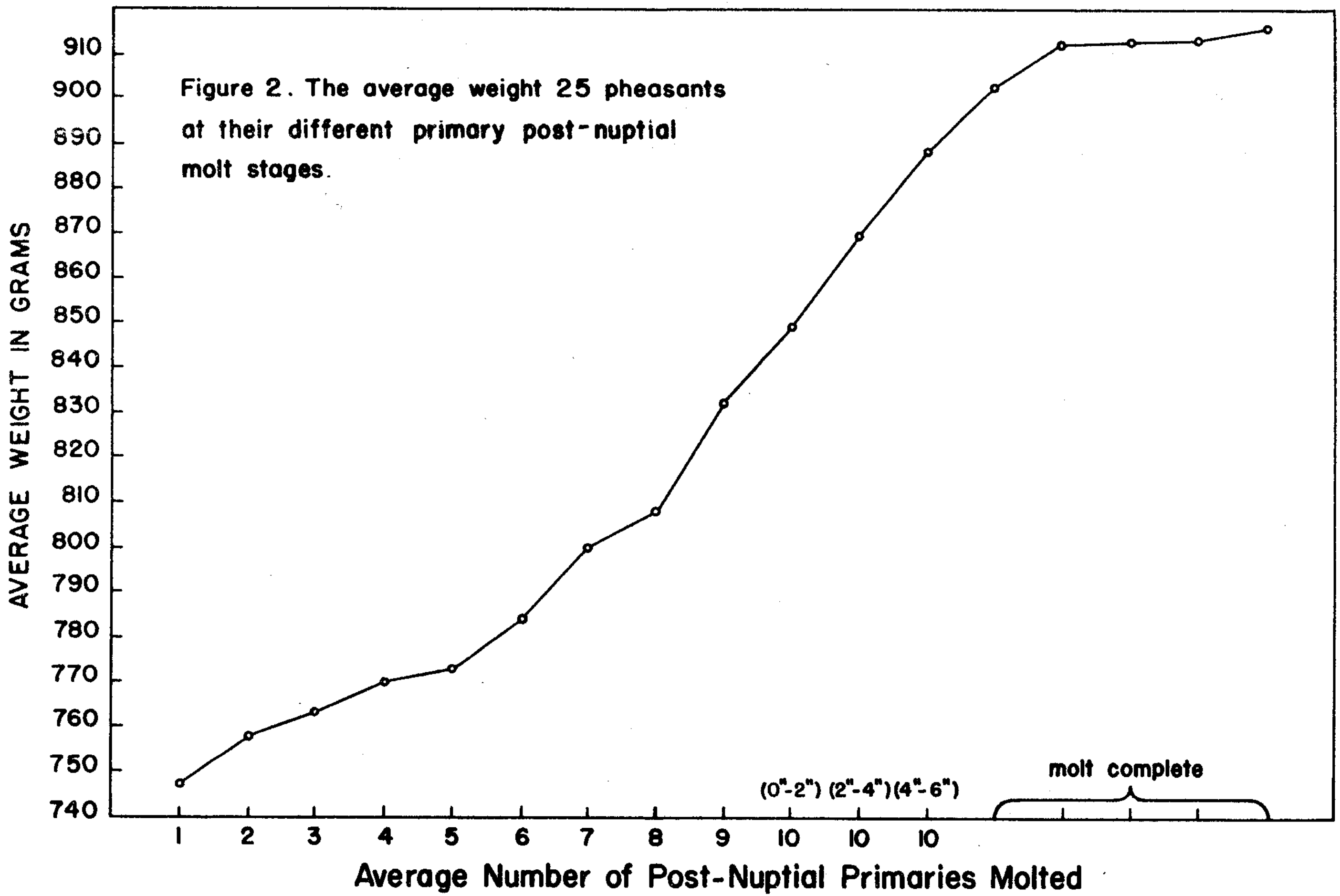

Figure 2. The average weight 25 pheasants at their different primary post-nuptial molt stages.