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# Adaptations of Female Bobwhites to Energy Demands of the Reproductive Cycle

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# ADAPTATIONS OF FEMALE BOBWHITES TO ENERGY DEMANDS OF THE REPRODUCTIVE CYCLE[1]

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Abstract: The energy required by bobwhites (Colinus virginianus) to attain reproductive condition was measured for 30 individually caged game-farm raised birds. They were acclimated to an eight-hour photoperiod, which then was increased one hour each week until reaching 15 hours; it was then kept constant. One hen began laying eggs five weeks after the 15-hour photoperiod started. However, only 75 percent of the birds that eventually layed were laying after 12 weeks at 15 hours photoperiod. Average body weights increased from 194.2 g seven weeks prior to egg laying to 214.8 g while laying. Metabolized energy increased 24.4 percent (35.6 to 44.3 kcal/bird-day) during the six weeks prior to the onset of yolk deposition, which occurs in the week prior to laying. Metabolized energy increased another 18.3 percent to 52.4 kcal/bird-day while the quail were laying eggs. These results show several adaptations of bobwhites that permit them to meet the energy demanding activity of achieving reproductive status. This asynchronous response to photostimulation enables the birds to optimize their time of lay to unpredictable weather conditions prevalent in spring in temperate climates. In addition, the energy required to achieve reproductive condition is spread over six weeks; thus, the impact of increased energy demands is minimized.

Previous studies have quantified the energy requirements of egg-laying in bobwhites (Case 1972). However, energy demands to achieve reproductive status and energy requirements of incubation have not been reported. The objective of this paper is to quantify the energy requirements to achieve reproductive status. In addition I will discuss how bobwhites apparently cope with the enigma of an assumed short food supply during an energetically demanding period.

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## METHODS

Thirty game-farm reared female bobwhites were individually caged under controlled photoperiod and a constant ambient temperature of 20 C. Food (chick starter, 21 percent protein and 4.2 kcal/g) and water were provided ad libitum.

Birds, feed, and excreta were weighed weekly. Approximately 0.5 hour prior to the onset of the photoperiod, feed and water were removed from the cages to ensure no ingestion of food or water immediately prior to weighing birds. Cages were cleaned and new feed was provided birds within 0.5 hour after the photoperiod started. Spilled feed and excreta (egested wastes plus nitrogenous wastes) were separated, then placed in individual petri dishes, and dried at 65 C for about 10 hours. Separation of feed and excreta was completed by sieving the mixture through a 10-mesh screen with gentle brushing. Separated feed and excreta were dried to a constant weight (usually 3 days). Birds, feed, and excreta were weighed to the nearest 0.1 g.

Feed and excreta were ground in a Wiley Model micro mill using a 20-mesh screen. Samples were weighed to the nearest 0.1 mg prior to calorimetric analysis in a Parr oxygen-bomb calorimeter.

Gross energy intake, excretory energy, metabolized energy, and existence energy, as defined by Cox (1961), were determined for each experimental bird. When birds maintained a constant body weight ($\pm$ 1 percent or less of body weight during a week), metabolized energy was termed existence energy, that is, the energy to exist under caged conditions.

Quail were acclimated to an eight-hour photoperiod for four weeks. The photoperiod was

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then increased one hour each week until 15 hours. Photoperiod remained constant throughout the duration of the experiment. Nest boxes, provided with excelsior, were placed in each cage. The onset of weight gain was assumed to represent gonadal growth and attendant increased body fat associated with the birds becoming reproductively active.

A sample of birds was sacrificed at the end of the experiment. Oviducts and ovaries were weighed to the nearest 0.1 g immediately after removal so as to determine the differences between reproductive and nonreproductive birds.

## RESULTS AND DISCUSSION

Twenty-four of the 30 experimental birds layed eggs. One hen commenced egg-laying five weeks after the 15-hour photoperiod began. However, it was not until 12 weeks after the onset of 15 hours light that 75 percent of the 24 egg-laying birds were laying eggs (Figure 1). Those results were unexpected for two reasons. First, since bobwhites start laying by 1 May in Kansas and Nebraska (Johnsgard 1979), it was anticipated that the threshold for photostimulation would be less than 15 hours. Second, regardless of a possible lower threshold for photostimulation, egg laying was expected to begin sooner than it did. Woodard et al. (1970) kept chukar partridge (Alectoris graeca chukar) on a short day, then increased the day length to 16 hours. First eggs were laid 21 or 22 days after photostimulation. A similar time is noted for domestic fowl to lay eggs following photostimulation.

Although the onset of egg laying was asynchronous among birds in this experiment, I assumed that the events leading to egg laying were time constant. Those events were manifest in increased body weights, which reflected proliferation of the reproductive tract and increased body fat. Thus, the event in common was egg laying. Body weights were averaged for each week preceding the start of egg laying (Figure 2).

Body weights averaged 194.2 g until seven weeks prior to egg laying. They then increased gradually, yet consistently, to an average 214.8 g. That weight is similar to the predicted body weights (216.2 g) of egg-laying bobwhites (Case and Robel 1974).

Metabolized energy was analyzed similarly to body weights. Metabolized energy averaged 35.6 kcal/bird-day through seven weeks prior to egg laying (Figure 3). Although metabolized energy appeared to increase eight weeks prior to the start of egg laying, seven weeks prior was chosen to be consistent with the data for body weights. Energy requirements for egg laying (52.4 kcal/bird-day) again were similar to 55.9 kcal/bird-day predicted by Case and Robel (1974).

King (1973) estimated the rapid phase growth (yolk deposition) of ovarian follicles for California quail (Lophortyx californicus) to be six to seven days. If this stage takes seven days for bobwhites, then the six preceding weeks represent the time to achieve full reproductive status. Average body weights increased 13.9 g over the six-week period. The average weight for the ovary and oviduct for nine reproductively active hens at the end of the experiment was 9.1 g. The average body weight increased only 6.7 g during the week prior to egg laying even though the average fresh weight of eggs was 8.7 g.

Over the six-week period metabolized energy increased an average 8.7 kcal/bird-day, which represents the requirement to achieve reproductive condition. The increase was 24.4 percent over existence energy requirements, yet

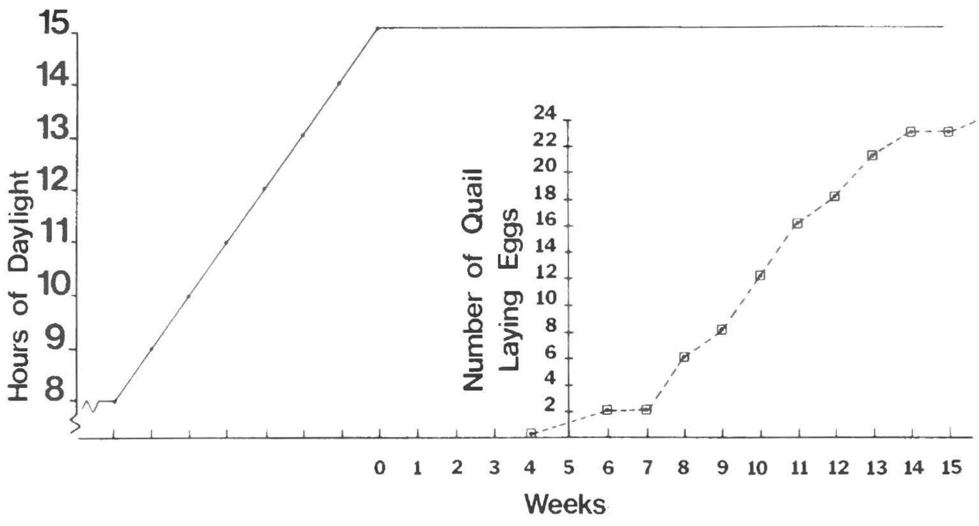


Fig. 1. Response time of quail to lay eggs following photostimulation.

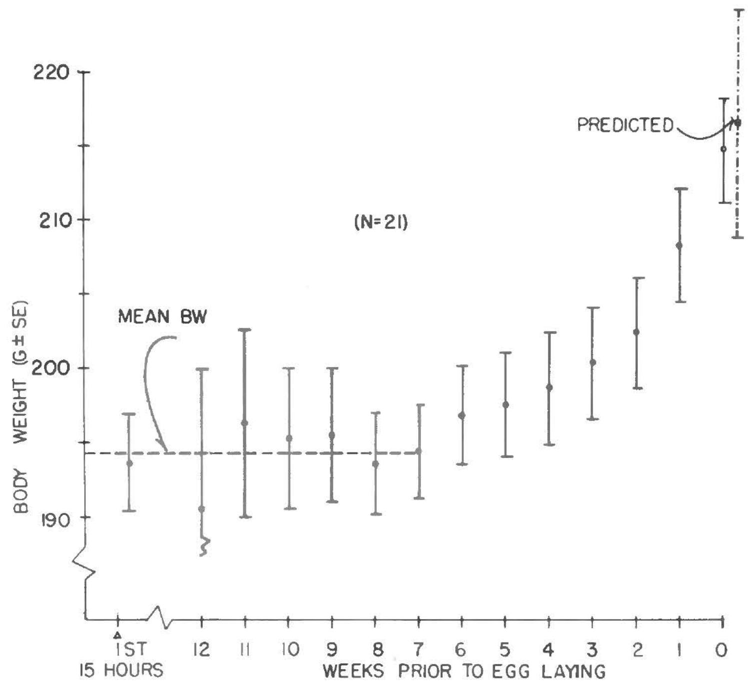


Fig. 2. Body weights of quail in response to photostimulation.

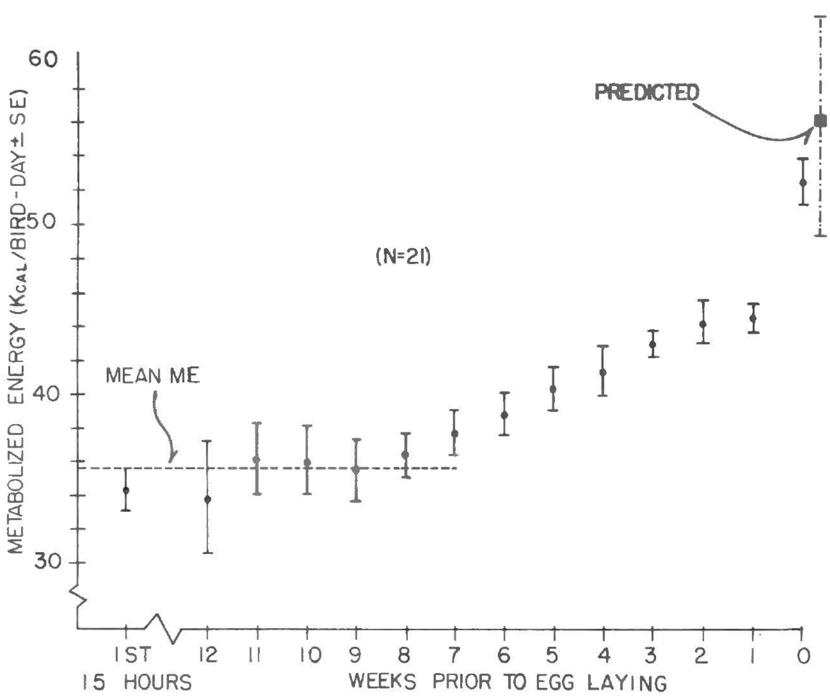


Fig. 3. Metabolized energy of quail in response to photostimulation.

on a daily basis, the increase was an average of only 0.85 kcal/bird-day. This increase does not reflect the energy cost for gonadal growth alone because body weight increased an average 13.9 g yet the average ovary and oviduct weight was only 9.1 g. Thus, the energy demand for gonadal growth is confounded with the energy requirement for adding fat. Metabolized energy in the week preceding egg laying averaged 8.1 kcal/bird-day more than the previous week, which represents an 18.3 percent increase.

Efficiency of egg laying was calculated as follows. During 645 bird-days 483 eggs were laid. The first five eggs for each bird were excluded in this analysis because they occurred at erratic intervals. The rate of laying was 0.75 egg/bird-day. Each 8.7 g egg would contain about 16.3 kcal (Case and Robel 1974). Metabolized (existence) energy for non-laying hens averaged 35.6 kcal/bird-day. The determined metabolized energy for egg laying was 52.4 kcal/bird-day, 16.8 kcal/bird-day greater than for existence. Then 12.2 kcal of egg (0.75 x 16.3 kcal) was formed each day at an additional energy expenditure of 16.8 kcal/bird-day, which represents 73 percent efficiency of egg formation.

## ADAPTIVENESS OF BOBWHITES TO REPRODUCTIVE ENERGY DEMANDS

It is nearly axiomatic that bird populations wintering in temperate regions are limited by food during winter (Lack 1966, Hespenheide 1973). Indirect evidence for this phenomenon in bobwhites can be inferred from the low survival rates of juveniles from September to April (Robel 1965, Robel and Fretwell 1970) and the decreased body weights of bobwhites over winter (Kabat and Thompson 1963, Robel and Linderman 1966, Roseberry and Klimstra 1971). Rosene (1969) suggested that egg laying and incubating female bobwhites experience a greater physical strain than males and consequently may die faster because they are weaker. This conjecture may be supported by studies that demonstrate a nearly equal sex ratio of juvenile bobwhites but an adult sex ratio in favor of males (Leopold 1945, Kabat and Thompson 1963). The energy demands of egg laying alone do not appear excessive since they are equivalent to existence energy requirements at rather moderate winter temperatures of -3.3 C (Case 1972).

However, the additional energy demand of attaining reproductive status at the end of winter (24.4 percent increase over existence) may be stressful since this is occurring prior to egg laying when food may be scarce. There appear to be two distinct adaptations of bobwhites to cope with this apparent enigma. First, the increased energy required for the onset of reproduction is amortized over a six-week period so that the energy needs increase gradually. In fact, the most energy demanding stage (yolk deposition) is delayed until the week prior to the onset of egg laying when food is more likely to be abundant. This time requirement, which is much greater than that for chukar partridge and domestic fowl, apparently is not an artifact of using game-farm reared birds. Anthony (1970), in a field study, reported that growth of the ovary and oviduct in California quail began in late March and egg laying in early May. He found that recrudescence of the oviduct was 8 to 10 and the ovary 10 to 12 weeks. The second adaptation is the asynchronous response time of bobwhites to photostimulation. Although bobwhites may start egg laying by 1 May, the peak occurs in late May (Johnsgard 1979). The early layers would have a reproductive advantage over other birds when winters are mild or spring weather is favorable and possibly may raise two clutches (Stanford 1972). Late layers would have an advantage following severe winters or late spring. This strategy would optimize quail reproduction by following the adage of not putting all their eggs in one basket.

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