FECUNDITY OF WILD NORTHERN BOBWHITE HENS UNDER HATCHERY CONDITIONS

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ABSTRACT

We describe egg production by 88 pairs of randomly selected, mature, wild-caught northern bobwhite (*Colinus virginianus*) hens housed under optimal conditions of food, water, climate, and a 17-hr photoperiod in a hatchery. We collected eggs daily using an 18-day period to differentiate between clutches. Hens continuously laid eggs until ceasing production. We evaluated number of eggs laid by each hen individually and hens collectively including total number, number/clutch, number/day, hatching success, and egg mass. Eighty-six hens produced 5,888 eggs. Number of eggs produced by individual hens ranged from 0 to 172 over ~ 200 days. Mean number of eggs laid/hen/day was 0.86. Clutch size ranged from 0 ($n = 2$) to 12 ($n = 1$). Mean number of eggs/clutch was 8.57. There was a strong correlation between clutch size and number of clutches. Some hens demonstrated continuous production of several large clutches. Hatching success of 5,793 eggs included for analysis was 61.6% (3,571 hatched, 2,222 failed to hatch). Hatched eggs had a greater mean mass compared to those that did not hatch.

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INTRODUCTION

Population studies of northern bobwhites were key factors in developing early concepts of wildlife ecology (Stoddard 1931, Leopold 1933, Errington and Hamerstrom 1935, Errington 1945), and numerous field studies have examined impacts of management on the demography of northern bobwhites, including components of fecundity (DeVos and Mueller 1993, Burger et al. 1995, Cox et al. 2005). Annual productivity depends on reproductive performance by hens buffered by environmental pressures. Northern bobwhite hens lay eggs at a rate of < 1 egg/day beginning 1 day after nest completion with completion of a clutch of 12–15 eggs in about 18 days (Rosene 1969, Dimmick 1992). Klimstra and Roseberry (1975) reported variation in clutch size ranging from 6 to 28 eggs. However, northern bobwhites reduce clutch size after each nest failure or clutch produced (Dimmick 1992). Maximum number of broods/female is not known definitively, but can be up to 3/breeding season (Guthery and Kuvlesky 1998). Percentage of hens capable of producing > 1 brood/year is unknown, but of those hatching a first nest, up to 30% may attempt a second (Burger et al. 1995). Questions about multiple-clutch production and clutch size remain unanswered because of a paucity of information on biotic potential of bobwhite hens. The objective of our study was to examine reproductive potential of northern bobwhite hens from southern Texas under controlled environmental conditions by assessing: (1) total eggs and number of clutches laid by individual hens and hens collectively, (2) hatching success (proportion of eggs hatched), and (3) multi-clutching (probability a female will continue laying clutches).

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METHODS

We captured wild northern bobwhites in walk-in traps (Reeves et al. 1968) on 2 ranches (27° 15′ 07.92″ N, 97°

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51′ 52.30″ W in Kenedy County, Texas and 26° 50′ 51.87″ N, 98° 13′14.82″ W in Brooks County, Texas) in April 1992 and January 1993. We released captured juveniles. We banded all adults with leg bands and placed them in 3.6 × 1.2 × 0.25 m holding pens for transport to the Texas State University Game Bird Alliance facility at the Freeman Ranch in San Marcos. Bobwhites were acclimated to captivity by slowly changing the diet from milo to Gamebird Layena (Ralston Purina, St. Louis, MO, USA) and replacing water in open poultry water basins to water supplied by modified, automatic drinking cups. We provided food *ad libitum* and refreshed it daily.

We transferred 88 adult males from holding pens in mid-February to a 5 × 5-m breeder room with a dual lighting system, a low intensity (60 W) blue light, and 13 high intensity (100 W) white incandescent lights. The breeder room had 3 banks of breeding cages (Model 0330, Georgia Quail Farms, Savannah, GA, USA) with 30 (25.6 × 61.5 × 25.6 cm) compartments per bank. Each compartment contained a modified automatic drink cup (Model 4086, Georgia Quail Farm, Savannah, GA, USA) at the rear and food tray at the front. Water and food were provided *ad libitum*. We maintained brood stock on a production diet consisting of Gamebird Layena and ground oyster shell (DeWhitt et al. 1949). All cages were in the same room with birds having visual and acoustical contact but not physical contact. All breeder cages received equal amounts of light from high-intensity white lights. An electronic timer (Model 1103, Tork Inc., Mount Vernon, NY, USA) controlled the photoperiod. Workers entering the breeder room to dispense feed or maintain equipment worked under low-intensity blue light. An evaporative cooler maintained a stable climate (temperature and humidity) (Vandepopuliere et al. 1969).

A single, healthy, adult male was placed in each compartment in mid-February and initially exposed to a 15-hr photoperiod to stimulate gonadal development and spermatogenesis (Kendeigh 1941, Robinson 1963). We paired males with adult hens from the same holding pen in early March but did not attempt to match individuals based on previous pairing because we could not recognize pairings in the holding pen. This arrangement was expected to produce the greatest fertility and hatching success rates (Schom 1973). We increased the photoperiod by 30 min every 5 days until a 17-hr photoperiod was established (Dozier and Bramwell 2002).

A constant 17-hr lighting treatment eliminated one of many variables influencing reproductive performance of breeder hens, namely, extent and timing of a light stimulus prior to the onset of egg production (Gous and Cherry 2004). The photoperiod with associated civil twilight (30 min before sunrise and 30 min after sunset at the latitude at which quail were collected exceeds 15 hrs/day. Civil twilight was included in the photoperiod used because birds are active before sunrise and after sunset (Palmgren 1949, Leopold and Eynon 1961). We assumed no difference in laying performance between birds on 17-hr instead of 15-hr photoperiod (Robinson 1963, Lewis 1996). We also tested an extreme photoperiod (17 hrs) as a component to elicit biotic potential by hens.

Egg collection began 30 March 1993 after acclimation of pairs to the 17-hr photoperiod for 21 days. We used 18 days to differentiate a clutch (Rosene 1969). We collected eggs daily from each compartment under blue-light illumination while wearing surgical latex gloves to prevent contamination. We marked each egg with sequential and compartment numbers with a soft lead pencil. We weighed each egg to 0.1 g on a digital balance (Model C305-5, Ohaus Inc., Florham Park, NJ, USA), wrapped all eggs produced/day/compartment in Saran™ plastic wrap to prevent moisture loss, and stored them in a refrigerator at a constant temperature of 12.8 °C (Miller and Wilson 1975). Eggs remained refrigerated between 7 and 14 days until incubation. Hart and Mitchell (1947) suggested storage of eggs should not exceed 10 days; we found no appreciable reduction in hatching success for eggs stored > 10 days in a pilot study when eggs were turned daily (Schom and Abbott 1974, Miller and Wilson 1976).

We removed eggs from the refrigerator and allowed them to reach ambient temperature (22 °C) before placement in an incubator. We assumed these eggs had equal fertility and potential hatching success. Eggs were incubated in an inverted position (i.e., small end up) to increase hatching success (Cain and Abbott 1971) for 21 days at a temperature of 37.5 °C and a relative humidity of 86–88%. We candled eggs for fertility at day 21 with a small penlight, transferred fertile eggs to a hatcher, and arranged them tightly to synchronize hatching (Pani et al. 1969). Eggs remained in the hatcher ~ 48 hrs at a temperature of 36 °C and relative humidity of 88–89%.

We terminated egg production at 202 days when hens began showing signs of physiological stress, declining egg production, fertility, and hatching success. All activities were conducted in accordance with Texas State University-San Marcos IACUC approval # CYOy 91–92 and Texas permit #SPR-0890-234. We used student's *t*-test to evaluate whether mass of fertile eggs differed from infertile eggs. We tested the relationship between mean eggs/clutch and number of clutches by an analysis of variance.

RESULTS

Eighty-six hens produced 5,888 eggs over a 202-day period (30 Mar to 19 Oct 1993), and 2 hens (2%) produced no eggs. These 86 hens collectively produced 687 clutches of eggs (mean ± SD = 8.57 ± 4.86; Table 1). Seventy-six hens (86%) laid at least 4 clutches, and 51 hens (58%) produced 9 clutches. The maximum number of clutches produced by a hen was 12 and 1 hen produced 172 eggs (11 clutches, mean ± SD = 16.3 ± 3.14). Intra-seasonal clutch size by clutch number was normally distributed and consistent across clutch number. Mean eggs/clutch increased from the first to third clutch, decreased slightly by the fourth clutch, and remained relatively stable through clutch 10, after which there was a substantial reduction in production (Table 1). This pattern of clutch number affecting clutch size was strongly

Table 1. Number of sequential clutches (C1-12) and mean (± SD), maximum (max), and minimum (min) number of eggs produced/clutch collectively by wild, northern bobwhite hens under 17-hr photoperiod in a hatchery.

Category	*n*	Mean ± SD	Max	Min
All	687	8.57 ± 4.86	28	5
C1	76	7.03 ± 3.74	18	5
C2	76	9.50 ± 5.06	28	5
C3	76	9.61 ± 4.99	23	5
C4	76	8.18 ± 4.84	24	5
C5	73	9.00 ± 5.21	19	5
C6	67	8.52 ± 5.23	22	5
C7	63	7.84 ± 5.08	21	5
C8	57	8.47 ± 4.93	18	5
C9	51	9.35 ± 4.44	18	5
C10	43	8.26 ± 4.40	16	5
C11	24	7.21 ± 3.92	18	5
C12	1	5.00 ± 0	5	5

correlated (second-order polynomial regression, $r^2 = 0.98$, $P > 0.001$; Fig. 1).

The mean (± SD) number of eggs laid/day was 0.86 ± 0.53. Hatching success of the 5,793 eggs included for analysis was 61.6% (3,571 hatched, 2,222 failed to hatch). Hatched eggs had a greater mean (± SD) mass (8.98 ± 1.94 g) compared to non-hatch eggs (mean ± SD = 8.83 ± 1.52 g; $t_{5,836} = -3.39$, $P = 0.001$).

DISCUSSION

The intra-seasonal clutch size remained consistent through clutch 9 in our hatchery study. This finding was surprising based on the extensive literature that a seasonal decline in clutch size is common in bird populations (Klomp 1970, Drent and Daan 1980, Martin 1987, Daan et al. 1989). Examples of this phenomenon include Arctic nesting geese (Hamann and Cooke 1989), temperate raptors (Dijkstra et al. 1982), and some passerines (Murphy 1986). Dimmick (1992) also reported reduction of clutch size after each nest failure or clutch event by bobwhites. Drent and Daan (1980) suggested that timing and variation in clutch size were based on accumulated body condition (i.e., accumulated nutrient reserves) required for egg production. Birds in poor condition might lead to the observed pattern of seasonal decline in clutch size (Daan et al. 1989).

Rowe et al. (1994) presented a model to explain multiple clutch production based on residual fitness. A hen will expend a certain amount of accumulated nutrients in laying her first clutch leaving a residual fitness based on unexpended nutrient reserves. There should be a time lag before she can start to accumulate condition for the second clutch. Her condition is assumed to decrease to a fixed level during this time interval. The loss of condition is assumed to be related to the amount of endogenous nutrients required for producing and rearing the clutch. Nutrients reserves needed to produce a second clutch will be less than the original reserves before production of the first clutch. One result of lower residual fitness may be fewer eggs in the second clutch. However, the results of our study did not indicate a continual decline in clutch size. The hen, for example, that produced 172 eggs showed a remarkable consistency in clutch size (18, 18, 16, 16, 19, 16, 17, 14, 15, and 8). There was no lag time in our study for replenishing nutrients, since eggs were continuously removed as laid. Perhaps the high quality diet fed to hens allowed maintenance of a sufficient nutrient reserve.

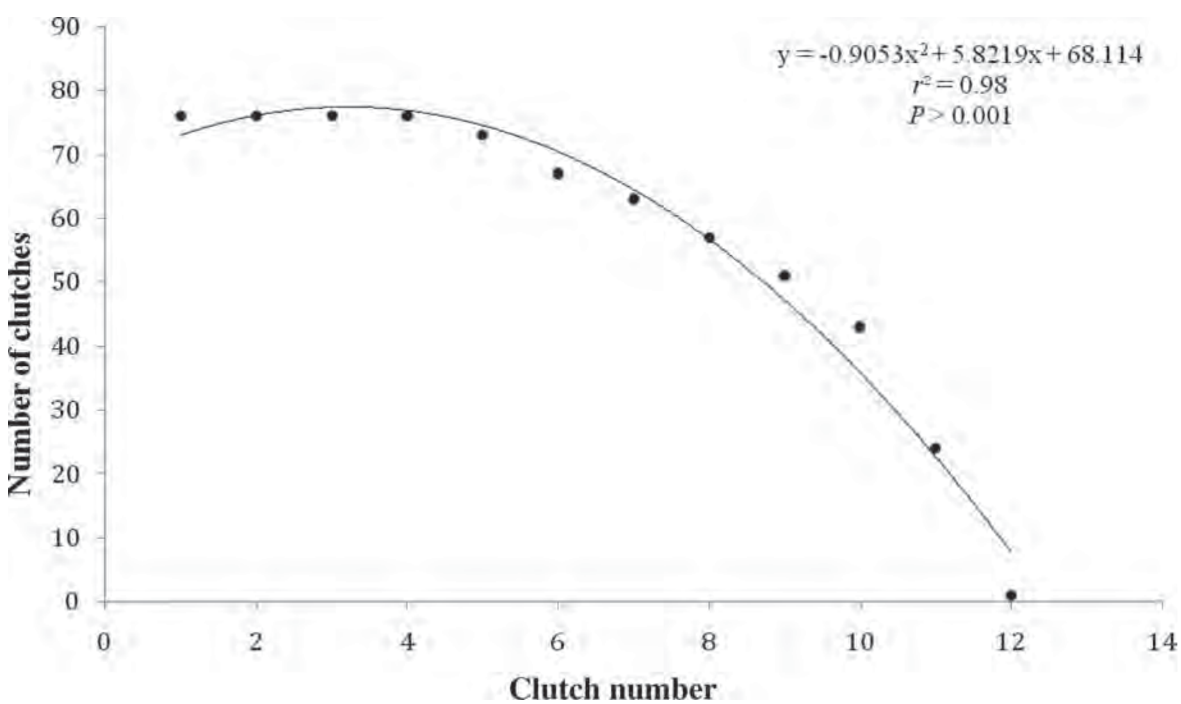

Fig. 1. Second-order polynomial regression showing the relationship between clutch size and clutch number.

Robinson (1963) reported mature captive bobwhite hens produced eggs with a mean mass of 9.65 g ($n = 143$); however, hens in our study produced eggs with a slightly less mean mass (8.98 g, $n = 3{,}571$) but heavier than the mean mass (7.78 g, $n = 96$) of young hens.

We showed that wild, captive northern bobwhites could produce multiple clutches of eggs. We suggest this species in a hatchery environment has high biotic potential as evidenced by 86 of 88 hens collectively producing 687 clutches of eggs with 61.6% hatching success over 202 days. Fifty-one of 86 (67%) hens produced 9 clutches, 51% of hens laid 10 clutches, 31% 11 clutches, and only 1 (1%) hen produced 12 clutches. Northern bobwhite hens in our study demonstrated differential reproduction and the potential in captivity to produce large numbers of eggs over at least 6 months under optimum conditions.

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