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NEST HATCH CHRONOLOGY OF NORTHERN BOBWHITE IN MISSOURI AND IMPLICATIONS FOR MANAGEMENT

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ABSTRACT

Managers in Missouri, USA, and in other Midwestern states have long operated under the belief that the peak of nest hatching for northern bobwhite (*Colinus virginianus*; hereafter, bobwhite) is 15 June. Though it is widely understood that bobwhite nests hatch throughout the summer, many management decisions are made based on the accepted peak. Fully understanding the dynamics behind bobwhite nest timing is critical, as management activities in nesting cover during summer are common. To better understand nest chronology, we used radio-telemetry to monitor nest incubation initiation, hatch date, and renesting rate on 6 conservation areas in southwestern Missouri from 2014 to 2018. Nest hatch date varied by area and year, but only 8.5% of nests hatched on or before 15 June. The 7-day interval during which the most nests hatched was 15–21 June, but we also saw high numbers of nests hatch in early July and mid- to late August. The median hatch date across all 5 years of the study was 17 July. Our results suggest that the entire summer is critical for bobwhite nesting activities, with late summer being just as important as the early summer months. We encourage bobwhite managers and conservation program policymakers across the Midwest to rethink previously held constructs of bobwhite nest timing. We also recommend that summer disturbances to nesting cover be kept to a minimum when the goal is to maximize bobwhite reproductive output.

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Reproductive ecology of northern bobwhite (*Colinus virginianus*; hereafter, bobwhite), including dates of peak nest hatch, has historically been used to inform habitat management activities (Stanford 1972, Klimstra and Roseberry 1975, Burger et al. 1995). For instance, researchers often recommend delaying summertime management activities such as hay harvest and routine mowing until after some defined peak of hatch. Government programs such as the Conservation Reserve Program administered by the U.S. Department of Agriculture also have rules prohibiting certain field disturbance practices until after the primary nesting season (PNS). However, nesting chronology, including peak hatch date, varies across the country and even among years (Stanford 1972). Research shows hatching occurs throughout the summer, with some nesting effort into September and October in places. Simpson (1972) found 2 peaks of nest initiation in Georgia, USA, as did Dimmick (1971) in Tennessee, USA. In northern Missouri, USA, mean incubation dates varied from 14 June for female incubated first nests to 15 July for male incubated first nests and incubation initiation occurred throughout the summer (Burger et al. 1995). Mean nest initiation dates for bobwhite in western Oklahoma, USA were 30 April for first nests and 17 July for second nests (Cox et al. 2005). Klimstra and Roseberry (1975) reported a mean hatch date for 213 nests in southern Illinois, USA, of 21 July and found "an essentially unfirm distribution" of hatches from 17 June through 18 August. Stanford (1972) used roadside observation of broods from June through August to demonstrate a peak hatch of 15 June, by which 27% of the annual production occurred in favorable weather years. He also noted that 64% of annual production in those years occurred before 15 July. He described these figures as Missouri's average production pattern. In years with higher-than-normal rainfall during the early nesting season, the average peak occurred 2 weeks later than during normal

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years. Additionally, Murray (1948) reported that 70% of nests on 2 central Missouri study sites hatched in May and June based on estimates of age from brood observations, though he noted that the hatch was likely earlier than normal due to a warm spring.

The historical Missouri research, especially the 15 June hatch peak, became the standard in Missouri for making management recommendations to landowners about summertime field activities. This hatch peak date is commonly provided in publications including the Missouri Natural Events calendar and other landowner management publications. Public land managers have used this date when making plans for haying, mowing, and prescribed burning. Policymakers with the U.S. Department of Agriculture's Farm Services Agency (FSA) have defined a primary nesting season of 1 May–15 July, during which certain management activities on Conservation Reserve Program (CRP) lands are not allowed. The idea is to restrict field activities during the period when most nesting and brood rearing of grassland bird species occurs. Field management is allowed outside of these dates, including the balance of the summer months.

Data obtained from wings of harvested bobwhites from the Robert E. Talbot Conservation Area in southwestern Missouri during 2006–2011 showed that few birds were hatched before 15 June (Loncarich, unpublished data). In fact, in some years no wings were collected from birds hatched before 15 June. This finding held significant implications for bobwhite habitat management on the area as field activities in the summer were long based on the 15 June hatch peak. As a result, there was potential that nests and vulnerable broods were disturbed by management that was occurring in late June–July.

As a part of a larger study on reproductive ecology of bobwhite in southwestern Missouri, we sought to use radio-marked individuals to determine hatching chronology across 6 study sites in southwestern Missouri. Bobwhite management is often the top priority for many landowners and certain public land areas, and it is critical to determine how nesting effort is spread out through the summer and to use that information to define better prescriptions for summertime management activities.

STUDY AREA

We tracked bobwhites on 6 publicly owned Conservation Areas (CAs) in southwestern Missouri: Robert E. Talbot CA in Lawrence County (1,764 ha), Bois D'Arc CA in Greene County (1,284 ha), Shawnee Trail CA in Barton County (1,471 ha), Wade and June Shelton Memorial CA (130 ha) and Stony Point Prairie CA in Dade County (516 ha), and Wah'Kon-Tah Prairie (WKCA) in St. Clair County (1,226 ha). Shawnee Trail CA and Bois D'Arc CA are composed of a mixture of native warm-season grass and forb plantings, grain crop fields and food plots, and old fields that consist of a mixture of early successional vegetation with scattered woody cover in the form of mature fencerows, shrub plantings, and brush-covered fields. Robert E. Talbot CA is similarly composed but has a significant open woodland and closed-canopy hardwood component. Wah'Kon-Tah, Shawnee Trail, and Stony Point Prairie conservation areas are remnant tallgrass prairies that contain scattered low-growing woody vegetation and areas of larger trees found in deep drainages.

METHODS

We trapped bobwhites in February–March with walk-in type funnel traps baited with corn and milo (Stoddard 1931). We sexed, aged, banded, and fitted trapped bobwhites with an approximately 4 g necklace-style transmitter with a live or dead sensor (American Wildlife Enterprises, Monticello, FL, USA). All birds were released at the capture site. Tracking began within 2 days of release and birds were located via homing ≥3 days/week beginning in May. We made every attempt to not flush the birds during tracking.

When a bird was found with a live signal in the same location >2 detections in a row, we assumed the bird was incubating. When incubating birds were detected off the nest, we would visually locate the nest and determine clutch size and nest condition. We tracked all incubating birds a minimum of 5 days/week until nests successfully hatched, were depredated, or were abandoned. Nests were classified as successful when ≥1 eggshells showed evidence of pipping. Depredated nests were classified by the presence of strewn and crushed shell fragments and obvious disturbance of the nest bowl. Nests were classified as abandoned if the incubating individual did not return to the nest after 5 consecutive days.

We categorized all nests hatched into 7-day intervals from 1 June through 5 October and plotted these through time to determine distribution. We had no nests hatch prior to 1 June or after 5 October. For this study we included only hatched nests for our nest timing analysis. Because technicians did not track all non-incubating birds on a site on a daily basis early in the nesting season and because no birds were tracked on weekends, we could not identify the exact date of incubation onset, and by extension, estimated hatch dates for unsuccessful nests. Therefore, unsuccessful nests were excluded from analysis.

RESULTS

We recorded 176 successfully hatched nests over 5 years. Only 10 nests, or 5.6% of the total, were hatched before 15 June (Table 1). We recorded 5 hatches on 15 June and when they were added to the 10 nests hatched prior to 15 June, the total represents 8.5% of all nests hatched. The busiest 7-day interval for hatching was 15 June–21 June when 23, or 13% of all nests, were hatched. Hatching remained steady through 12 July, by which time 48.7% of nests had hatched, and hatching tailed off during mid- to late July (Figure 1). A second peak of hatching occurred 27 July–6 September, when 38.5% of nests hatched. Hatching activity dramatically declined later in the summer, with only 16 nests hatching after 1 September.

Table 1. Number of nests hatched and percentage of total hatch for each 7-day interval for northern bobwhite (*Colinus virginianus*) in Missouri, USA, 2014–2018.

7-day Interval	Number of nests	Percentage of total nests hatched
1–7 Jun	2	1.1
8–14 Jun	8	4.5
15–21 Jun	23	13.0
22–28 Jun	15	10.2
29 Jun–5 Jul	14	8.5
6–12 Jul	20	11.4
13–19 Jul	8	4.5
20–26 Jul	7	4.0
27 Jul–2 Aug	16	9.0
3–9 Aug	8	4.5
10–16 Aug	9	5.1
17–23 Aug	17	9.7
24–30 Aug	10	5.7
31 Aug–6 Sep	8	4.5
7–13 Sep	2	1.1
14–20 Sep	6	3.4
21–27 Sep	1	0.60
28 Sep–4 Oct	2	1.1

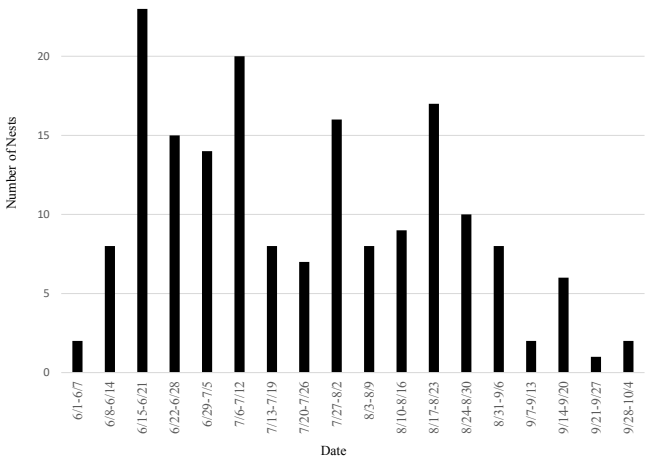

Fig. 1. Nest hatch chronology for northern bobwhite (*Colinus virginianus*) in Missouri, USA, across all study sites pooled from 2014 through 2018.

Hatching chronology was also plotted by Julian date to provide a better representation of distribution of hatching across years (Figure 2). Median hatch date for our study based on Julian date was 17 July.

DISCUSSION

Our results showed 2 peaks of hatching activity (Table 1). However, the entire summer period was important for hatching, as shown by the median Julian date of hatch. Like Stanford (1972), we found significant bobwhite nest hatching in June. However, the percentage hatched on or before 15 June

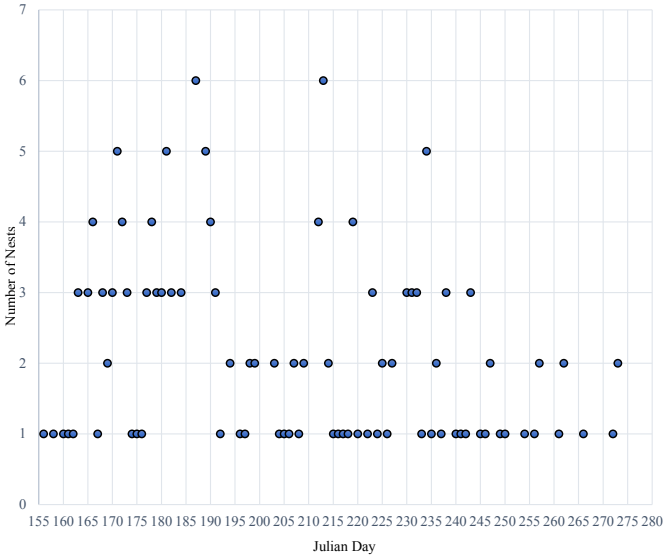

Fig. 2. Julian date nest hatch chronology for northern bobwhite (*Colinus virginianus*) in Missouri, USA, across all study sites pooled from 2014 through 2018.

in our study was only 8.5%, compared to Stanford's 27%. Additionally, Stanford's finding of 64% of nests hatching prior to mid-July is counter to our results. The hatching rate for May and June from our study is even more disparate from Murray (1948) as we had no nests hatch in May. Our results matched closely those of Klimstra and Roseberry (1975), who found similar peaks of hatching and a mean hatch date of 21 July. However, the distribution of hatching in their study was more uniform throughout the summer than ours.

Stanford's (1972) determination of the June peak of hatching relied on roadside observations of broods by field agents during their routine activities. These agents estimated the age of broods based on body size, and variation among observers relative to estimating brood age likely existed. Whether the bias resulted in an overestimation of age for observed broods is unknown. Stanford's determination of the full nest hatching chronology also included examination of primary feather replacement on hunter-harvested wings. From these data he defined a second peak of hatching of around 15 August. The estimated date of hatch based on hunter-harvested wings data may have been a better estimate of true hatch date than the roadside observations as they more closely align with other published estimates of hatch dates and our radio-collared bird findings. However, Klimstra and Roseberry (1975) found that backdating wings underestimated the percentage of birds harvested after 29 July by nearly 16%, thus possibly overestimating the amount of early hatched clutches. Whatever the case, estimation of peak hatch date based on backdating wings and estimates from roadside observations of broods are less reliable than radio-telemetry or other nest observation studies.

While our data differ from the widely cited and applied historical Missouri data, the emphasis should not be on

whether our data concur. Methods of determining nest hatch were vastly different among the studies and may not be directly comparable. The extent to which climate differences between the mid-1900s and our study resulted in the disparate findings is unknown, but it is doubtful that climate change could explain the wide disparity in results. Whatever the cause, the differences are less important than our finding that the entire summer period is critical for nesting bobwhites. While hatch date was our focus, it is important to remember that the date of hatch is merely the culmination of a nesting season that can take up to 55 days (Rosene 1969). A nest hatched on 1 July was initiated in mid-May and a nest that hatched on 15 Sept was initiated in early August. The entire late spring through late summer is of critical importance to nesting bobwhites.

MANAGEMENT IMPLICATIONS

The historical emphasis on the 15 June peak of hatch date in Missouri, whether to make local habitat management decisions or statewide policies, has been misplaced. The inference has been that after 15 June, or after 15 July in the case of Conservation Reserve Program policy, field management can occur without fear of harming most nests or vulnerable broods. Our data, however, show that bobwhite nest in significant numbers throughout the summer. Even if most nests were hatched on or before 15 July, vulnerable broods would still be threatened by large-scale disturbances such as prescribed fire, mowing, haying, and heavy disking for at least 2 weeks after hatch (Rosene 1969). We recommend that management activities which will cause disturbance to nesting habitat occur prior to 1 May, before most nests are initiated, or after 15 September, when most nests are hatched, if the primary goal is bobwhite management. This will not only protect nests, but also minimize management-related disturbance of vulnerable chicks due to direct mortality or displacement.

We also urge the U.S. Department of Agriculture's Farm Service Agency in Missouri and nearby states with a similar bobwhite nesting chronology to reevaluate the primary nesting season or allowable management therein. The number of active nests and vulnerable broods on the landscape after 15 July is significant and heavy disturbance of nesting cover in late July and August could cause unacceptable losses of nests and broods. This may be especially evident where native grass CRP fields represent most of the available nesting cover in a local area.

Delaying management until mid-September will require tradeoffs. Mowing native warm-season grass hay in late summer will result in lower protein content in the hay but is likely to produce more tons of hay per acre. Prescribed fire is essential for managing bobwhite habitat throughout much of the species' range. Fire can temporarily reduce plant density and increase bare ground, control woody plant succession, and increase forbs (Engle and Bidwell 2001), and we encourage expansion of prescribed fire. Many managers implement prescribed fire in the summer to reduce woody encroachment and increase forbs. However, Weir and Scasta (2017) found that prescribed fire in July and August increased woody plant cover in tallgrass prairie whereas September and October fires reduced woody plant cover. They also found that burning in September and October resulted in a greater forb response than July and August burns. Forbs are critical for insect attraction and seed production for bobwhite food. If disturbance must occur during the summer months, we encourage managers to disturb one-third or less of local nesting habitat and focus on the most successionally advanced cover to reduce the chance of encountering nests and vulnerable broods (Sinnot et al. 2021).

There is some argument that disturbance which causes nest loss early in the season can be mitigated by the bobwhite's propensity to renest. While renesting does occur, we found that only 13% of birds in our study renested after a first nest was destroyed (Loncarich and Hedges, unpublished data). Therefore, the success of first nests is vital, and it is important to reduce habitat management activities during May through September in areas where the potential for bobwhite nests is high.

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