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BROOD SIZE OF EASTERN AND MOUNTAIN BLUEBIRDS IN MANITOBA

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Beginning in 1959, an extensive network of approximately 4000 nest boxes for bluebirds was established and maintained in southwestern Manitoba. Although both Eastern (*Sialia sialis*) and Mountain bluebirds (*S. currucoides*) were indigenous to the area (Criddle 1927), lack of natural nest cavities was believed responsible for low populations. Populations of both species expanded rapidly in response to availability of artificial nest sites (Miller 1970).

During 1970–1974 the late John Lane banded and recorded field notes on 11,462 nestling bluebirds in 2609 broods. Both bluebird species are migratory and reach distributional limits within the study area. Mountain Bluebirds are in the extreme northeastern and Eastern Bluebirds the extreme northwestern portions of their breeding ranges (Zeleny 1976). Range overlap provides an opportunity to observe the two species under syntopic conditions. In this paper we analyze Lane's banding records and field notes to discern the number, size, and timing of broods.

The study area lies within a 200 km radius of Brandon, Manitoba (49°50'N, 100°00'W). Physical characteristics of the area have been reviewed by Munro (1981).

METHODS

Data used in analyses included species identification, number of young per brood, and date of banding. Nestlings were not banded until they were at least 8 days old. The percentage of broods banded per week was used as a measure of breeding chronology.

RESULTS

Between 1970 and 1974, 1727 nestling Eastern Bluebirds were banded from 427 broods (Table 1). Annual mean brood sizes ranged from 3.78 to 4.19, and the 5-year mean was 4.04 young per nest. Analysis of variance indicated no significant differences ($P < 0.01$) in brood sizes during the 5 years. Among Mountain Bluebirds, 9735 nestlings were banded from 2182 broods. The 5-year mean of 4.46 young per nest approximated the annual means and no variation was evident among years ($P < 0.01$).

Variations in the number of broods banded each year were proportional to the number of days of banding effort (Mountain Bluebirds r_s = 1.00, $P < 0.02$; Eastern Bluebirds r_s = 0.80, $P < 0.10$; both species r_s = 0.90, $P < 0.02$). The numbers of broods banded in different years probably did not reflect population changes.

The number of young per brood ranged from 1 to 6 for Eastern

TABLE 1. Number and mean sizes for all broods and broods in first and second banding peaks for Eastern and Mountain bluebirds in Manitoba, 1970–1974.

Year	No. days of banding	All broods			First peak broods		Second peak broods	
		No. young	No. broods	$\bar{x}$ brood ± SD	No. broods	$\bar{x}$ brood ± SD	No. broods	$\bar{x}$ brood ± SD
Eastern Bluebirds								
1970	32	267	65	4.11 ± 1.17	27	4.33 ± 1.24	25	3.88 ± 1.03
1971	47	401	96	4.19 ± 1.12	28	4.57 ± 0.94	35	3.94 ± 1.09
1972	61	586	144	4.06 ± 1.16	26	4.09 ± 1.09	62	3.92 ± 1.10
1973	38	227	57	3.98 ± 0.95	7	4.00 ± 1.12	29	3.83 ± 1.02
1974	49	246	65	3.78 ± 1.16	18	3.98 ± 1.33	26	3.50 ± 1.28
Totals	227	1727	427	4.04 ± 1.12[1]	106	4.24 ± 1.38[1,2]	177	3.85 ± 1.11[1]
Mountain Bluebirds								
1970	32	1204	270	4.46 ± 1.49	135	4.95 ± 1.46	92	3.78 ± 1.33
1971	47	2014	448	4.49 ± 1.38	113	4.87 ± 1.47	227	4.33 ± 1.26
1972	61	3141	689	4.56 ± 1.29	289	4.90 ± 1.29	258	4.53 ± 1.33
1973	38	1372	311	4.41 ± 1.38	91	4.81 ± 2.43	161	4.28 ± 1.35
1974	49	2004	464	4.32 ± 1.32	187	4.63 ± 1.22	142	3.82 ± 1.38
Totals	227	9735	2182	4.46 ± 1.37[1]	815	4.83 ± 1.34[1,2]	880	4.23 ± 1.32[3]

[1] No significant difference in column means for this species, $P < 0.01$ by ANOVA.
[2] First peak $\bar{x}$ broods are significantly larger than second peak $\bar{x}$ broods for this species, $P < 0.03$ by Mann-Whitney U-test.
[3] Significant difference in column means for this species, $P > 0.05$ by ANOVA.

Bluebirds and 1 to 8 for Mountain Bluebirds. Most common brood sizes were 3, 4, and 5 in Eastern Bluebirds (cumulative, 85% broods), and 4, 5, and 6 in Mountain Bluebirds (cumulative, 78% broods). Nests with 7 young comprised 2% of the Mountain Bluebird sample, but broods of 8 were rare (n = 5, <1%).

Time of banding for Eastern Bluebirds.—Peaks in the number of Eastern Bluebird broods banded were irregularly bimodal in all years except 1973, when a first peak was virtually lacking (Fig. 1). First and second peaks were clear enough among years to suggest that many pairs nested twice. First peaks, however, were equal to second peaks in number of broods banded only in 1970 and 1974. Low first peaks in 1971 and 1972, and the absence of a first peak in 1973, suggest significant losses of first nests in either the egg or early brood stages. First peaks occur as early as the first week of June (1972) and as late as the first week of July (1970) indicating wide variation in timing among years. Although banding effort varied among years, it did not vary greatly during a given season.

The 5-year average curve suggests that first banding peaks are irregular and second peaks more synchronous for Eastern Bluebirds. Inter-

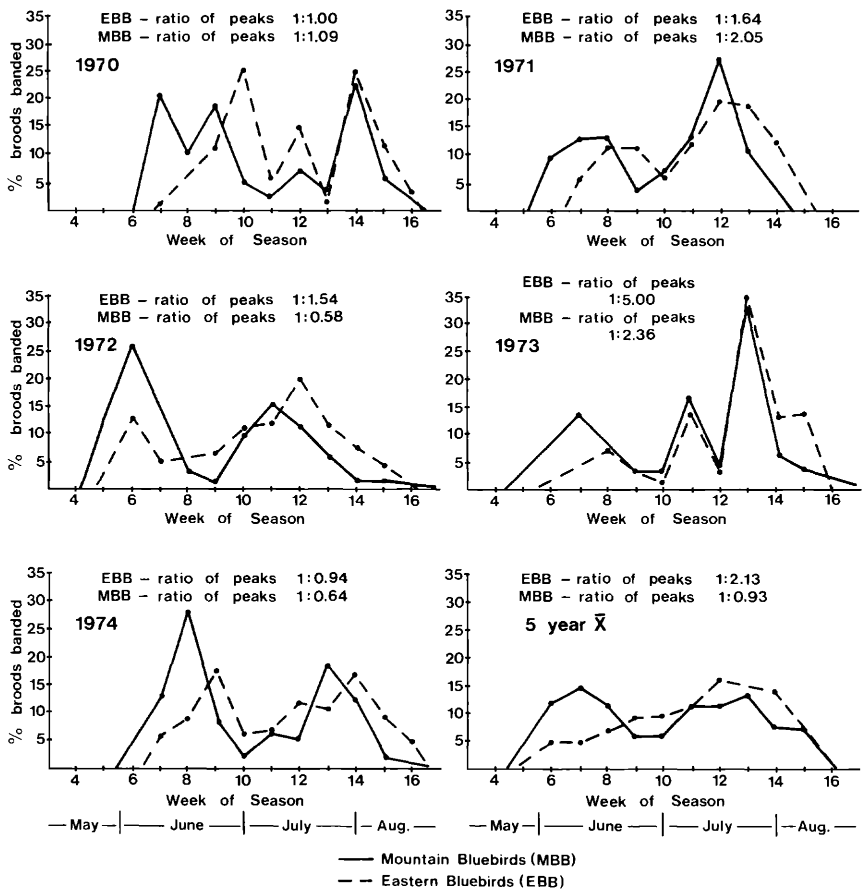

FIGURE 1. Percentage of Eastern and Mountain bluebird broods banded per week during the breeding season in southwestern Manitoba, 1970–1974.

mediate peaks are evident in 1970 and 1974 and may have resulted from either late arriving pairs or re-nestings by pairs whose first attempt was destroyed early in the season. The intermediate peak in 1973 resulted from poor weather restricting banding effort during the second week of July (Fig. 1). We have no evidence of successfully reared third broods and suspect that broods banded in early August are late second nestings.

Reproductive cycle for Mountain Bluebirds.—Banding peaks were bimodal for Mountain Bluebirds in all years (Fig. 1). In 1970, 1972, and 1974 early peaks were equal to or exceeded late peaks in number of broods, but in 1971 and 1973 late peaks were higher, suggesting loss of first clutches or young nestlings. Weak intermediate peaks were evident in

1970 and 1974. The split second peak in 1973 resulted from poor weather restricting banding effort. Five-year average records indicate bimodality and equality in early and late brood production by this species over time.

Size comparison of broods in first and second banding peaks.—Banding peaks typically occurred over 2–3-week periods (Fig. 1). Broods banded during each peak were analyzed to determine variation in size for each species (Table 1). Mean sizes of broods for the first banding peak for Eastern Bluebirds ranged from 3.98 to 4.57 and did not differ significantly among years ($P < 0.01$, ANOVA). The 5-year mean first brood size was 4.24. Broods in the second banding peak were smaller in all years and did not differ significantly among years ($P < 0.01$, ANOVA). The second peak 5-year mean of 3.85 was significantly smaller than the 5-year first peak mean ($P < 0.03$, Mann-Whitney U-test).

Mountain Bluebird broods were larger than those of Eastern Bluebirds in 9 of the 10 comparable banding periods (Table 1). The number of young in early broods of Mountain Bluebirds did not vary significantly among years ($P < 0.01$, ANOVA), but that in late broods did ($P > 0.05$, ANOVA), suggesting greater variation in late broods for this species. The 5-year mean for first broods was significantly larger than that for second broods ($P < 0.02$, Mann-Whitney U-test).

DISCUSSION

Mountain Bluebirds usually arrive in southern Manitoba in mid-March, but may arrive as early as the first week and as late as the last week of March depending on snow-melt and temperature (Randall and Lane 1969, Miller 1970, Lane 1971, Lane and Bauman 1972, Lane and Burton 1974). Although Eastern Bluebirds occasionally appear at the same time as Mountain Bluebirds (Lane and Bauman 1972), they typically arrive about 2 weeks later (Miller 1970). Pinkowski (1977) noted that migrant Eastern Bluebirds in Michigan arrived over a 1-month period and that general arrival occurred at least 1 week later than appearance of first migrants. This pattern is repeatedly mentioned in Lane's field notes for both species in Manitoba, although suspected new arrivals continued to appear until mid-May for Mountain Bluebirds and the first week of June for Eastern Bluebirds.

Both bluebird species commonly produce second broods. Krug (1941) stated that about 70% of Eastern Bluebirds produced two broods in Ontario, and Pinkowski (1977) reported two broods as common in Michigan. Peakall (1970) estimated that 87% attempted second broods in various areas of North America. Randall and Lane (1969) initially suspected few second broods, but subsequent observation indicates that Eastern Bluebirds commonly produce second broods although the percentage of attempts and success are unknown (Lane et al. 1978, 1979, pers. obsv.).

Mountain Bluebirds produce second broods in many areas (Power 1966, Scott 1967, Pinel 1980). Randall and Lane (1969) estimated that

50% of Mountain Bluebirds produce second broods, and Criddle (1927) suggested that both species usually produce two broods in Manitoba. Banding records suggest a high number of second broods for both species (Fig. 1).

The timing of banding peaks suggests that second peaks represent second nests rather than late first nests. We cannot unequivocally state, however, that all young recorded as second nestings were second broods. Subsidiary peaks evident between major banding periods in some years are believed to represent either late first nestings or second attempts by pairs with unsuccessful first nests that were destroyed early in the first cycle.

Eastern Bluebird broods banded during first (mean 4.24 young) and second (mean 3.85 young) peaks in Manitoba are similar to those found in successful nests in Ontario where first broods averaged 4.38 and second broods 3.73 young (Krug 1941). Pinkowski (1977) reported 4.11 young per successful first nest and 3.28 per successful second nest in Michigan. Our all-brood mean size of 4.04 nestlings (Table 1) is slightly greater than values of 3.73 young in Michigan (Pinkowski 1979), 3.80 in Ontario (Krug 1941), and 3.32–3.54 in Florida (White and Woolfenden 1973).

Mountain Bluebird nests in Manitoba averaged 4.83 young in early broods, 4.23 young in late broods (Table 1), and 4.46 young for all broods. These values are comparable to first brood sizes of 4.88 in Alberta (Pinel 1980). Average all-brood sizes in Manitoba, however, are slightly smaller than those of 5.04 and 4.75 young reported in 1979 and 1980 in Alberta (Stiles 1980, 1981). Known second broods were smaller than first broods for both species in all areas.

Because young were banded 8 or more days after hatching, our data represent late-stage nests. The apparent low number of first broods in several years, therefore, does not necessarily reflect the number of nesting attempts. Low numbers of first broods in banding data may indicate losses in early nesting attempts by one or both species in years when first peaks were lower than second peaks. Low first peaks were coincident for both species in 1971 and 1973, but occurred only for Eastern Bluebirds in 1972 (Fig. 1). The values and lack of variation of means within first and second broods among years suggest that losses involve whole clutches or entire broods.

Two major factors may cause heavy losses in early nests. First, the study area is subject to late spring freezes, cold rainy periods, and snowstorms in May. Cold weather during the egg laying, incubation, or early nestling periods often results in nest desertion or death of either or both young and adults (Kibler 1969, Lane 1971, Scott 1974, Pinkowski 1977). Weather conditions that encourage early nesting, therefore, may lead to nest destruction during later inclement periods (Musselman 1939, Krug 1941, Lane and Burton 1974).

Second, weather conditions conducive to early nesting in Manitoba also are conducive to outbreaks of black flies (*Simulium* spp.) during the early nestling stage (pers. observ.). Heavy first brood losses to black flies were suspected locally in both bluebird species in 1970, 1972, and 1974 (Lane and Bauman 1972, Lane and Burton 1974). For example, Lane and Bauman (1972) estimated a 13% loss of first brood young in 1972. First broods also appeared more susceptible to interference by House Sparrows (*Passer domesticus*), least chipmunks (*Eutamias minimus*), red squirrels (*Tamiasciurus hudsonicus*), and deer mice (*Peromyscus maniculatus*).

Qualitative statements in the literature suggest several possible relationships between weather and timing of breeding. Time of arrival of migrant populations varies among years, but because bluebirds are early migrants, weather during early spring may not be important as long as adults survive. Nest-building, however, may be prolonged during cold weather, and warm dry weather in late April and early May often results in early initiation of first clutches (Smith 1937, Krug 1941, Kibler 1969, Erskine and McLaren 1976, Stiles 1981). If conditions remain favorable after early nesting begins, more second broods may be reared (Stiles 1981). Pinkowski (1979) reported shorter brood times associated with warm dry weather.

Relationships between weather and initiation of first nestings by bluebirds are poorly documented, and the magnitudes of critical variables have not been defined. Although we believe that weather conditions account for the temporal variations in banding peaks among years in our data (Fig. 1), available breeding records are not precise enough to attempt definitive analysis. Similarly, the timing and severity of black fly outbreaks were not monitored in the study area.

The unique aspect of bluebird breeding chronologies in Manitoba appears to be the relationship between number of broods in first and second banding peaks. We believe that a combination of inclement weather and early nest destruction in the study area combine to limit the success of first nesting attempts for both species. Weather pressure (see Pinkowski 1977) was greatest in 1971 and 1973, when warm dry conditions induced early nesting and were followed by prolonged cold spells in late May. Black flies were locally abundant in 1971, 1972, and 1974. The fact that the number of broods in the first banding peak was lowest in 1973 suggests that cold wet weather may be the most important factor.

Similarly, suspected black fly predation destroyed many first broods in 1972 but did not greatly depress the first banding peak for Mountain Bluebirds. Banding peaks were later in 1970 and 1974 because of late arrival of warm spring weather. Accordingly, both species nested later and were not subject to late freezes (Fig. 1). The 5-year ratio of peaks suggests that Eastern Bluebirds may be more susceptible to early losses than are Mountain Bluebirds.

A perplexing problem evident in the chronologies is greater synchronization in second peaks than in first peaks. One would expect the opposite trend because early re-nestings, late arrivals, and production of second broods would be staggered (see Pinkowski 1977). Our only explanation for the pattern evident in the data is that early re-nesting and late arriving pairs are subject to much greater competition for nest boxes with Tree Swallows (*Tachycineta bicolor*) and House Wrens (*Troglodytes aedon*) (Munro 1981), and second banding peaks may be synchronized by availability of nest sites (pers. observ.).

If second banding peaks are synchronized by availability of nest sites, some pairs nesting in the second peak may have been unable to nest earlier, and, consequently, are nesting for the first time. These would be improperly classified as second nests in our data, and necessitate caution in interpretation of data. Greater synchronization of first broods, however, has been reported from areas that are not as susceptible as the study area to adverse early season weather conditions. Accordingly, first nests of bluebirds that are destroyed by weather may be replaced by first nests of other species that are ready to breed somewhat later in spring. Bluebirds then may have to wait for available boxes before attempting second nests. In this case, second nestings would be correctly classified in our data and synchronization becomes a function of nest site availability.

Although Eastern and Mountain bluebirds were syntopic before nest boxes were erected (Criddle 1927), their populations have increased with the provision of artificial cavities. Our data suggest that brood size has not been affected by syntopy. The effects of increased competition and nesting success, however, are not addressed by our data. Close ecological relationship between the species is attested to by hybridization within the study area (Rounds and Munro 1982).

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