LATE SUMMER-AUTUMNAL BREEDING OF THE PIÑON JAY IN NEW MEXICO

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The variety of cues used as proximate factors in timing of breeding emphasizes the adaptive nature of the reproductive cycle in birds. In most temperate zone species photoperiodism seems to be paramount, although a few apparently breed largely independently of photoperiod (Tordoff and Dawson 1965). In contrast, rainfall is often the most important single factor initiating nesting in the deserts of central Australia (Keast 1959; Immelmann 1963).

Piñon Jays (*Gymnorhinus cyanocephalus*) often breed early as compared to most other North American passerines. Jensen (1923) states that in New Mexico the nesting season extends from February to June (also see Bailey 1928). Breeding occurs in February following a large piñon (seeds of *Pinus edulis*) crop, apparently as a result of the abundant food. The jays store piñons throughout the fall and early winter and subsist largely on this food during the winter and early spring. In years following poor piñon production breeding is delayed until April or May when other foods, principally insects, become common (Ligon, unpubl. data). There is one early record of synchronized very late breeding. J. S. Ligon recorded nestlings in October 1916 in southwestern New Mexico (Bailey 1928). This report deals with late summer-autumnal breeding of the Piñon Jay in the same region.

LATE SUMMER BREEDING NEAR MAGDALENA, NEW MEXICO

In August 1969 Piñon Jays bred at 7200 ft in mature pinon-juniper (*Juniperus monosperma*) woodland 12 mi. W of Magdalena, Socorro County, New Mexico (fig. 1). This flock has maintained a range of about 6.2 × 1.8 miles for at least a year and a half.

No piñons were produced in the fall of 1968. Although observations began in late March 1969, I obtained no evidence of nesting until 14 May when I saw several pairs carrying nest material and five pairs working on nests in middle or late stages of construction. When I returned on 25 June, I found that none of the nests had been used and in some cases they had not even been completed. During the morning I watched small flocks of jays as they foraged, and noted a single fledgling. Food apparently was in short supply, as there were frequent fights over food items in old, dried horse manure. The birds foraged quietly, intently, and continuously throughout the morning and early afternoon. I made no observations in July. On 12 August nest building was noted and on 19 August many pairs had started nesting.

ENVIRONMENTAL FACTORS

Factors other than photoperiod obviously are significant in timing of breeding. Figure 2 illustrates the seasonal nature of precipitation at the Magdalena Weather Station, with about 60 per cent of the average annual precipitation falling as afternoon thunderstorms in the three-month period, July–September. (Rainfall is spotty in the southwest and precipitation recorded at the Magdalena Station is not precisely the same as that at the study area.) Rainfall in July and August, especially, promotes growth of grasses and other vegetation, which in turn stimulates reproduction in various insects. These rains undoubtedly are important in making successful reproduction possible in August and September, as immature insects form the main food of the nestlings. However, rainfall probably is not of primary importance, as autumnal breeding did not take place in August 1970, even though rainfall was greater than in 1969.

Another factor is the piñon crop. In 1969 a bumper crop was produced over much of New Mexico, including the study area. Some jays tore open cones and removed the unripened nuts as early as 25 June, although these were not a major component of the diet at that time. By 12 August piñons formed a main food, as judged by stomach contents, although the green cones still were tightly closed and vigorous efforts were required to extract the nuts. Piñons probably were the most important environmental stimuli initiating breeding. Experimental studies of captive Piñon Jays suggest that availability of piñons stimulates reproductive activity (Ligon, unpubl. data).

Jays collected 19–20 August were about 10 per cent heavier than those taken in June,

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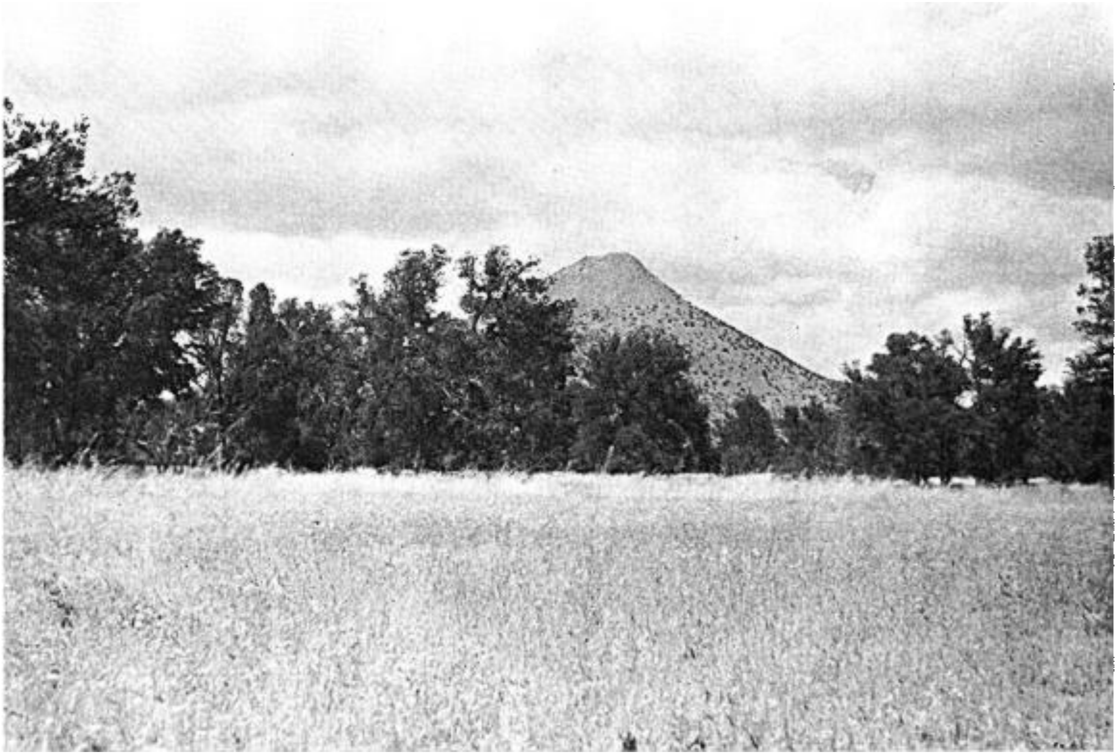

FIGURE 1. Piñon-juniper woodland 12 mi. W of Magdalena, Socorro County, New Mexico.

presumably as a result of the superabundant food. (One small tree possessed more than 1800 cones.)

Summarizing, presumably as a result of abundance of piñons and summer rains which brought about a greatly increased insect fauna, synchronized breeding began 12–19 August 1969, three months after the aborted nesting effort of mid-May and over six months later than the earliest nesting activity recorded in this region.

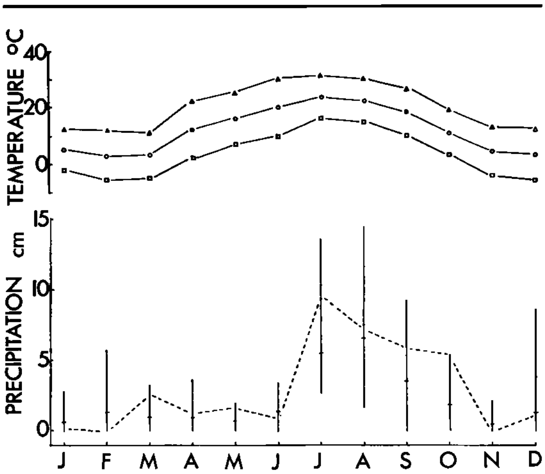

FIGURE 2. Upper. Monthly temperature data (mean maximum, mean minimum, monthly mean) for 1969 from Magdalena, Socorro County, New Mexico. Lower. Monthly precipitation at the same site. Vertical lines indicate the 20-year (1948–1968) range; horizontal lines, the 20-year average; and broken line, monthly totals for 1969.

NESTING

Timing of the major events of the late summer-autumnal nesting is shown in table 1. I found 14 nests distributed over an area of 0.8 × 0.7 miles. Often two or three nests were close together and well separated from similar clusters. Data from three nests indicate that egg laying followed completion of the nest by two or three days.

TABLE 1. Timing of events in late summer breeding of Piñon Jays near Magdalena, New Mexico.

Event	Dates
Courtship behavior	12–20 Aug.
Nest building	12–26 Aug.
Egg laying	16 Aug.–3 Sept.
Incubation[a]	20 Aug.–17 Sept.
Nestlings[b]	5–30 Sept.
Fledging	27 Sept.–7 Oct.
Dependency of fledglings	7 Oct.–6 Nov.
Postjuvenal molt	28 Oct.–30 Dec.

[a] Incubation period is 17 days.
[b] Nestling period is ca. 20 days.

TABLE 2. Foods brought to nestling Piñon Jays.

Date	Age of nestlings	Food items
20 Sept.	8 days	*Sceloporus undulatus*; cf. Pyralidae larvae (4); Myrmeleontidae larva (1); nymphal Acrididae (7) and Gryllidae (1); adult coleopteran (1); pieces of piñon (2).
23 Sept.	7 and 11 days (2 nests)	Acrididae, adults (8), nymphs (19); cf. Pyralidae larvae (12), adults (4); coleopteran larvae (3); Phasmatidae (1); Gryllidae (1 nymph); Araneida (7); Scorpionida (1); whole piñons (3), halves (2); gravel (2).
23 Sept.	18 days	Acrididae, adult (1), nymphs (2); cf. Pyralidae larvae (2), adult (1); whole piñons (2); gravel (1).

Clutch size for 12 nests was as follows: two nests with three-egg clutches, five nests with four-egg clutches, and five nests with five-egg clutches. Jensen (1923) found five-egg clutches in only six of 54 nests. The high average clutch size of the August breeders probably is correlated with the abundant food supply. Two eggs failed to develop in each of two five-egg clutches.

Care of nestlings. Young were fed by both parents. I sampled foods brought to nestlings by wrapping pipe cleaners around the necks of the nestlings so that they could not swallow. Adults feed young by regurgitating food carried in the throat, and all may be fed by one adult during a single trip to the nest. Table 2 lists foods given to nestlings. Note that piñons made up only a small portion of the nestlings' diet.

No traces of grasshoppers were recorded from stomachs of eight adults taken on 10 or 23 September, although these formed a major food brought to nestlings on 20 and 23 September (table 2). The distal portions of the hind limbs of the grasshoppers were almost always broken off cleanly and the heads were removed from all of the lepidopteran larvae, suggesting that these foods were prepared for the nestlings. Scarab beetles were not recorded from nestlings, although remains of these were found in the stomachs of most adults collected in the period August–November.

Nestlings appeared to be well cared for at all nests but one. On 20 September the three unfeathered occupants of this nest were obviously badly undernourished. Unlike other young that I checked, they also were cold, indicating that the female had not brooded them recently. Three days later only two emaciated, but still living, nestlings remained. Orians (1960) and Payne (1969:77) found desertions to be common in fall-breeding Tricolored Blackbirds (*Agelaius tricolor*).

At one nest three adults were in attendance on 20, 23, and 30 September. All behaved in a solicitous manner when the nest was examined. The age and sex of the additional bird was not determined. Although additional adults or nest helpers might be expected in this highly gregarious species, in view of the widespread occurrence of this trait in certain other New World corvids that occur in much smaller groups (e.g., *Aphelocoma coerulescens coerulescens*, Woolfenden and Westcott, paper read at 1969 A.O.U. meeting; *A. ultramarina*, Brown 1963; *Cyanocorax dickeyi*, Crossin 1967; *Psilorhinus mexicanus*, Skutch 1960), I did not find this usually to be the case. I looked for helpers at other nests but, with two possible exceptions (three birds were seen at two new nests) in addition to the instance mentioned above, I failed to detect more than two birds attending any nest.

Post-fledging care. Following fledging, juvenile Piñon Jays congregate in groups. Initially they are incapable of prolonged flight and remain perched quietly while the adults are away. For example, on 16 October at 07:30 I watched about 300 adults leave the juveniles behind by flying rapidly to a great altitude as they departed. The young birds perched quietly in groups (10 in one tree) after the adults left. Upon the return of the adults at 08:00 the fledglings began calling noisily and flying to them. The adults left after the juveniles were fed, returning to feed them at 08:15, 08:50, and 09:23, after which time I left. By 23 October the juveniles flew strongly and accompanied adults as the latter stored piñons; however, they still were fed by the old birds. On 6 November a juvenile was observed feeding independently on a piñon, although begging was still frequent. An occasional begging call was heard through December.

I have no evidence that non-breeding adults provide food for fledglings. It is probable, however, that non-breeders do at least occasionally respond to vocalizations, wing-waving, and gaping of juveniles by feeding them.

Breeding success. I found 14 nests in all.

TABLE 3. Molt of female Piñon Jays in relation to breeding condition.

Date	Breeding condition	Molt[a] Remiges	Rectrices
26 Aug.	Incubating; had laid final egg on this date.	Primaries: 1–7, grown; 8, ⅘ grown; 9–10, old. Secondaries: 1–2, 7–10, new; 3, growing; 4–6, old.	Pairs 1–3, grown; 4–5, ensheathed at bases; 6, old.
23 Sept.	No brood patch.	Primaries: 1–9, new; 10, old, left wing; 1–10, new, right wing. All secondaries, replaced.	All replaced.
23 Sept.	No brood patch.	All primaries, replaced. Secondaries: 1–4, 7–10, new; 5, growing; 6, old.	All replaced.
23 Sept.	Fresh brood patch.	Primaries: 1–8, new; 9–10, old. Secondaries: 4–6, old; others, new.	No molt; outer pair, old.
23 Sept.	Fresh brood patch.	Primaries: 1–7, new; 8–10, old. Secondaries: 5–6, old; others, new.	All replaced.
16 Oct.	Fresh brood patch.	Primaries: 10, old, left wing; 9–10, old, right wing. Secondaries: 4, short quill; 5–6, old; others, new.	All replaced.
23 Oct.	No brood patch.	Molt complete.	
6 Nov.	Brood patch being refeathered.	Primaries: 10, ensheathed, left wing; 9–10, ensheathed, right wing. Secondaries: 5, growing; 6, gone; others, new.	All replaced.
20 Nov.	Brood patch being refeathered.	Primaries: molt complete. Secondaries: 6, ensheathed at base.	All replaced.

[a] Body feathers are not considered here.

The female parent was collected at one; no more than four of the other 13 nests were successful. These four produced a maximum of 13 young. Low nest success may be usual, as Balda (in litt.) found the same for spring-breeding Piñon Jays in the Flagstaff, Arizona, area. However, my visits may have contributed to the failure of some nests. I recorded several potential predators in the nesting area that may have been attracted by the concentration of jays. These include: bobcat (*Lynx rufus*), Cooper's Hawk (*Accipiter cooperii*), Barn Owl (*Tyto alba*), and Great Horned Owl (*Bubo virginianus*). In addition, Scrub Jays (*Aphelocoma coerulescens*) watched me as I climbed to two new nests that each contained one egg. Both were empty on my next visit. A pair of Piñon Jays vigorously drove away a Scrub Jay from their nest tree. A nest which contained four healthy young on 20 September held only one living and one freshly killed nestling on 23 September. The dead bird had small puncture wounds on both sides of the head. Its position in the nest was natural. Cameron (1907) noted young Piñon Jays disappearing at intervals from the nest and determined that shrikes were taking them.

As fledglings appeared in early October it became apparent that I had failed to find most nests. On 16 October I located about 50 fledglings. By projecting the fates of the nests that I located (4 of 13 successful; 3.25 young per successful nest), I estimate about 15 successful nests out of 50 attempted, or one fledgling per nest. Prior to breeding, the flock consisted of about 300 birds. If the assumptions concerning the number of nests are valid, about one-third of the flock attempted to breed in August. This figure agrees with the sample of 10 birds I collected on 19–20 August (three adult breeders, two adult non-breeders, five immature non-breeders).

AGE OF LATE SUMMER BREEDERS

Methods used to age Piñon Jays will be presented in detail elsewhere. These include ossification and pillaring of the skull, characteristics of the remiges (mentioned also by Brodkorb 1936), and mouth color.

One-year-old birds apparently breed only when environmental conditions, principally food availability, are ideal. Of six first-year females collected at a site near El Morro, Valencia County, New Mexico, 16 May–23 June 1969, none possessed a brood patch, whereas all of four adult females taken did so. Breeding was late in this flock, presumably as a result of food shortage in late winter and early spring, and it appears that first-year birds did not participate. However, at least two first-year females with brood patches were collected from the Magdalena group in spring 1970, where piñons were abundant. All of the

TABLE 4. Molt condition and testis volume of adult Piñon Jays in late August 1969 and 1970.

Dates	n	Molt condition: Primaries	Molt condition: Rectrices	Testis vol. (mm³)
19–20 Aug. 1969	4	8–10 or 9–10, old. Preceding primary ⅓–½ grown.	Variable; first (innermost) to first 3 pair, grown; outer 2 pair, old, to outer 3 pair, growing.	301.0 (59.6–413.4)
25 Aug. 1970	3	9 and 10, grown, but ensheathed at bases.	Replacement complete.	13.9 (8.8–18.4)

six fall-breeding females collected 26 August–20 November 1969 were at least two years old.

MOLT AND REPRODUCTION

In August 1969 breeding began when jays were in the late stages of molt. A female taken on 26 August, a few hours after laying the last egg of her clutch, was actively molting. Certain other temperate zones species, ecologically similar to the Piñon Jay in their dependence on an irregular food source (Clark's Nutcracker, *Nucifraga columbiana*; Red Crossbill, *Loxia curvirostra*), may begin the molt in the early stages of the reproductive cycle (Mewaldt 1958; Kemper 1959). However, only the Piñon Jay is known to begin breeding while in the latter half of the molt cycle.

An additional interesting relationship between molt and breeding is demonstrated: an interruption of molt during the breeding period. Table 3 gives molt stages and reproductive condition of females collected August–November. Only the molt of remiges and rectrices is indicated. Note especially the molt conditions of the four jays taken on 23 September; in breeding birds molt is suspended. Male Piñon Jays exhibit a similar pattern.

In four of five breeding females taken prior to 20 November, primaries 9 and/or 10 were retained during the height of reproductive activity. In the other jay, primaries 8–10 were held. The similarity of the stage at which molt stopped, in males as well as females, suggests a precise relationship between molt and breeding. Possibly factors stimulating molt (hormones) spontaneously decreased following the loss of primary eight, or gonadotropin production may have increased as a result of environmental stimuli, suppressing molt.

GONADAL CYCLES

Although no jays were collected between 25 June and 12 August, it appears likely that gonadal competence was retained through the summer by those birds which bred in August. Several indirect lines of evidence support this conclusion. First, it is unlikely that gonadal regression and regeneration could occur in that short period. Marshall and Coombs (1957) found the regeneration period of another corvid, the Rook (*Corvus frugilegus*), to be about four months. Second, some of my captive birds that had not bred in the spring maintained sexual behaviorisms, principally courtship feeding, throughout the summer. Others that had nested, did not. These points are supported by the pattern of reproduction in 1970, when the great majority of birds bred successfully February–June and no evidence of reproductive activity was apparent in August (see table 4). The pattern of early breeding and early refractory period or delayed breeding and late refractory period is known for other species with unusual breeding schedules, e.g., Tricolored Blackbird, *Agelaius tricolor* (Payne 1969:99).

DISCUSSION AND CONCLUSIONS

It is apparent that Piñon Jays possess great lability regarding inception of breeding. By late December some males have enlarged testes (Ligon, unpubl. data). If conditions are suitable, the birds breed in early February. However, if food is scarce, as in early 1969, breeding is postponed in most birds, perhaps for several months. Gonads probably remain partially enlarged during this time, with the jays being responsive to environmental cues stimulating reproduction. This pattern closely follows Marshall's (1961) scheme of antagonistic environmental "accelerators" and "inhibitors." Other temperate zone species show fluctuations in gonad size unrelated to the refractory period (Selander and Hauser 1965; Payne 1969:98).

Molt of Piñon Jays collected near Magdalena in June and August 1969 was delayed as compared to jays taken at the same site in 1970 when breeding began in February (table 4). The delay in 1969 may be related to shortage of food, and possibly to repression of molt by gonadotropic activity, maintained at a high level in the absence of culmination of the breeding cycle. Payne (1969:66) found that molt is delayed in late breeding individuals of *A. tricolor*, and Mewaldt (1958) states that molt begins considerably later in the Clark's Nutcracker when food scarcity prohibits breeding than when breeding is general.

Initial evaluation of interrupted molt in the August breeding Piñon Jays is likely to be that it is adaptive in that the two energy-requiring processes (molt and reproduction) are not performed simultaneously. Although this is probable, interrupted molt in this case may be an incidental effect of the overlap of the two processes. Food is abundant at this time and temperatures are mild. It would seem advantageous for the female at least to complete the molt while she incubates, as she is fed by the male. However, molt stops in breeding birds of both sexes.

Interdigitation of breeding and molt is rare in passerines of the Northern Hemisphere. The abbreviated molt schedule of the Steller's Jay (*Cyanocitta stelleri*) on Queen Charlotte Island is timed together with breeding to coincide with food abundance of the short summer (Pitelka 1958). However, molt and breeding are completely separated (Johnson 1963). Passerine species of the temperate zone which demonstrate some interspersion or overlap (e.g., Clark's Nutcracker, Red Crossbill, and Piñon Jay), have in common an unusually strong dependence on an irregular food source (Mewaldt 1958; Kemper 1959). Simultaneous breeding and molt may be less rare in Australian deserts where birds breed at any time of year in response to rainfall (Keast 1959; Immelmann 1963).

Piñon Jays exhibit characteristics related to breeding similar to those of other species faced with irregular food supplies (Immelmann 1963; Tordoff and Dawson 1965). These include extended periods of reproductive competence, interdigitation or some degree of overlap of breeding and molt, nomadism, possibly a long term or permanent pair bond, and a high degree of sociality.

SUMMARY

Piñon Jays (*Gymnorhinus cyanocephalus*) bred in August–September 1969 in pinon-juniper woodland 12 mi. W of Magdalena, Socorro County, New Mexico. Little reproduction occurred the previous spring when food was scarce. In August a bumper piñon crop was maturing and the jays fed extensively on piñons. In addition, many insects, particularly immature forms, became available as a result of the late summer rains. These were fed to young.

It appeared that many jays maintained reproductive competence throughout the summer. The jays were in late stages of the molt cycle when nesting began in mid-August. Molt was interrupted in breeding birds during the nesting period.

Breeding biology of the Piñon Jay in southwestern New Mexico appears similar to that of the Red Crossbill (*Loxia curvirostra*) of North America in that breeding may occur irregularly in response to certain environmental cues, namely food, and is little influenced by climatic conditions per se, occurring at the same site in February or August.

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