FLOCKING AND ANNUAL CYCLE OF THE PIÑON JAY, *GYMNORHINUS CYANOCEPHALUS*

RUSSELL P. BALDA

AND

GARY C. BATEMAN

Department of Biological Sciences
Northern Arizona University
Flagstaff, Arizona 86001

Although detailed studies have been conducted on many North American jays (Pitelka 1945, 1951; Hardy 1961; Brown 1963, 1964, 1970) little information beyond Bent's (1946) brief description is available on the Piñon Jay. For a number of reasons this species is one of the more unusual members of the family Corvidae found in North America. It is a very early nester, initiating egg laying as early as February in Piñon–Juniper Woodland (Jensen 1923) and also in ponderosa pine (*Pinus ponderosa*) (this study) at elevations of 7000 ft. This jay is also known to form exceptionally large flocks, at times containing thousands of birds (Bent 1946). During years of poor seed crops in conifers, especially piñon pine (*Pinus edulis*), flocks may become nomadic and move hundreds of miles outside of their normal range (see Westcott 1964). Although flocking in many species is a response to harsh or unfavorable environmental conditions (Emlen 1952), the Piñon Jay maintains a tightly knit and probably highly integrated flock year round.

This report describes the activities of a flock of jays and its members throughout the different periods of the year. Because the yearly cycle contains periods during which very different requisites are needed, we will try to show how these demands are met within the context of a flock. Since the study flock spent a large share of its time in a somewhat unusual habitat, Ponderosa Pine Forest, some of the observations and conclusions may differ from those resulting from studies in the more typical Piñon–Juniper Woodland.

METHODS AND DESCRIPTION OF STUDY AREA

Observations described herein were made on a flock of about 250 Piñon Jays in an area 10 mi. NE of Flagstaff, Arizona. Observations commenced in February 1968 and continued through September 1970. Detailed notes were kept on the seasonal variation in flock behavior and size, geographic movements, feeding behavior, and intra- and inter-specific social interactions. During the nesting seasons of 1968 and 1969, up to 80 birds in the flock were marked with plastic color bands and United States Fish and Wildlife Service metal bands. Young birds were banded either as nestlings or were caught by hand immediately after fledging. Adults were captured with mist nets strategically placed around mounted skins of Great Horned Owls (*Bubo virginianus*). Piñon Jays actively mobbed the owls by swooping down at them in a frenzied flight which often resulted in their flying into the nets. It was not uncommon to have 10–15 birds mobbing and scolding the owl at the same time. Mist nets scattered along the routes of travel of the flock or placed around tethered young birds yielded poor catches.

Swarth (1924) records this species as abundant in the Flagstaff area, especially in the Piñon–Juniper Woodland, but he also noted that Piñon Jays used agricultural crops as food. (The fields that once supported corn and beans now lie fallow.) Mearns (1890), however, noted that the species extended to the upper limits of ponderosa pine in the San Francisco Mountains near Flagstaff. The area surrounding Flagstaff was searched for Piñon Jay flocks, and six flocks were located within a 15-mile radius of the city. No new flocks have entered this area, and all six flocks had relatively specific home ranges during 1968 and 1969 but wandered over much wider areas in the fall of 1970. Two of these flocks nest within the city limits, and another just at the city limit. One of these flocks made frequent visits to a feeding station at which almost continual observations were made. Birds were captured, marked with plastic backtags, and transplanted from this flock to areas inhabited by other flocks.

The area normally utilized by the Piñon Jay flock under study was at least 8 square miles and encompassed at least three distinct plant communities (fig. 1). This general area has numerous cinder cones, the remains of past volcanoes which rise 200–300 ft above the surrounding lowlands. The substrate over much of the area contains large amounts of black and red cinders. Because of poor water holding capacity of these cinders, the soil seldom freezes for long periods of time, thus enabling the Piñon Jays to probe for seeds and insects throughout the winter when ground elsewhere is frozen.

The most extensively inhabited plant community was second-growth Ponderosa Pine Forest (fig. 2). Ponderosa pine is the dominant tree, with piñon pine, alligator juniper (*Juniperus deppeana*), Rocky Mountain juniper (*Juniperus scopulorum*), and Gambel oak (*Quercus gambelii*) contributing less than one per cent of the total tree density. The pines are spaced well apart so that the canopy is open, and the trees are of markedly different ages.

Another portion of the study area supported Piñon–Juniper Woodland, and was dominated by piñon pine and various species of *Juniperus*. Shrubs were numerous and the major contributors to this layer were spe-

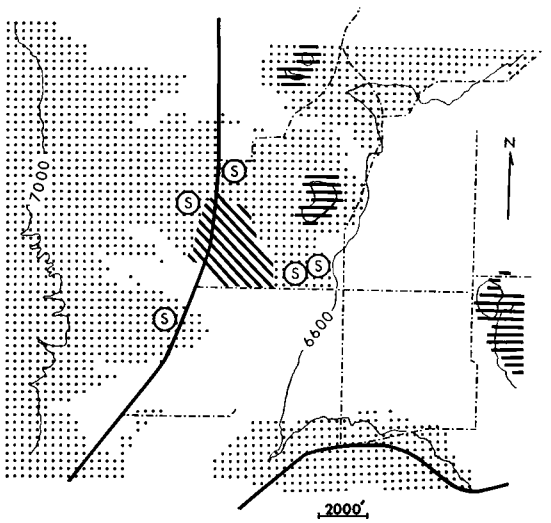

FIGURE 1. Map of the home range of the Piñon Jay flock. Dark, heavy lines indicate major roads, dashed lines, secondary roads. Dotted area indicates distribution of Ponderosa Pine Forest; horizontal lines, Piñon–Juniper Woodland; and open areas, grassland. Oblique lines show location of traditional nesting grounds. S indicates locations of satellite colonies.

cies of *Purshia*, *Chrysothamnus*, *Ceanothus*, and *Gutierrezia*. This plant community was restricted to dry south- and east-facing slopes of three cinder hills which rose above the Ponderosa Pine Forest (fig. 3).

The third type of habitat used by the jay flock consisted of fields that have lain fallow for the past 20–40 years and are now used sparingly as pasture. The predominant grasses and forbs of this habitat consist of *Bouteloua*, *Helianthus*, *Cleome*, *Verbascum*, *Salsola*, *Monolepis*, *Amaranthus*, *Chenopodium*, *Artemisia*, and *Aster* (fig. 3). Some of these open fields were up to 2400 acres in size. That a jay flock used this same area for at least two years prior to the initiation of this study was ascertained by locating old nests and by questioning local residents.

YEARLY FLOCKING CYCLE

NON-REPRODUCTIVE PERIOD

From late October or early November the flock of jays under study numbered between 200–250 individuals. Blue adults and gray, first-year birds were scattered throughout the loosely organized flock. When settled into an area to feed, the flock at any one time occupied an area of about two acres during the periods of most intensive feeding (morning

FIGURE 2. Ponderosa Pine Forest showing the dense understory of grasses and forbs and the unevenness of the pine canopy.

FIGURE 3. Cinder cones supporting ponderosa pine and Piñon–Juniper Woodland in background and open field in foreground.

and evening), and up to six acres during the remainder of the daylight hours. Individual birds were sometimes very close to one another at a prime feeding site or scattered 20–40 ft apart in more open spaces. Clumps of up to 20 individuals often fed together within an area of about 60 sq ft. Aggressive encounters were few in these clumps, but occasionally one bird displaced another by pointing its bill at the intruder. During this aggressive display, the head and neck feathers were depressed and the neck outstretched. A single rapid flap of the wings often accompanied this display. Displacement was also achieved by simply flying with legs outstretched at the subordinate bird. The latter most often moved away, but occasionally it would stand its ground and point its bill upward at a 50–70° angle, thus exposing its white throat. This display is somewhat similar to that which Goodwin (1952) describes as the chin-up display of *Garrulus glandarius* and *G. lanceolatus*. However, the Piñon Jay does not crouch nor fluff its belly plumage while performing the display. At a rich food site, birds often bumped into one another, or even landed on the backs of others. This occurred when snow covered much of the ground and the birds were forced to forage under the canopies of pines, often near the tree trunks where the snow depth was less than that out in the open. An interesting and apparently unusual case occurred at two salt blocks near a cattle watering tank. During 7 hr on two different days, the jay flock visited this location five times. The jays frantically flocked around these blocks, hammering off and then eating small flakes of salt. The jays stood shoulder to shoulder, and often bumped one another. Birds approached the flock by flying over it and simply landing on the backs of other jays, causing them to move. Some birds ingested the soil in the immediate vicinity of the salt blocks. In all, up to 28 birds were seen crowded around each of the blocks with no apparent aggressive encounters.

During late fall and early winter when snow was absent, the flock spent about 80 per cent of its time in the pine forest and 10 per cent

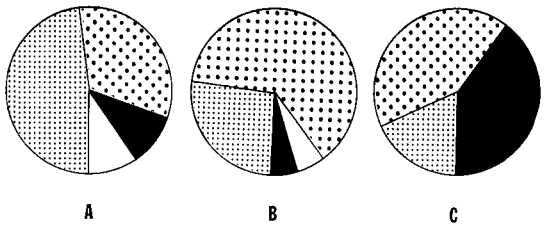

FIGURE 4. Foraging sites of the Piñon Jay flock during non-reproductive period (A), nesting period (B), and fledgling period (C). Dotted areas = per cent of time spent in Ponderosa Pine Forest (large dots, foraging on ground; small dense dots, foraging in foliage), black area = per cent of time spent in Piñon–Juniper Woodland, and clear portion = per cent of time spent in grassland.

in both the open meadow and woodland (fig. 4). They used grassy meadows more during this period than at other times of the year. When snow was present, the flock spent about 60 per cent of its time in the woodland where snow seldom completely covered the ground. It was common to see Piñon Jays eating snow, and at times this was their sole source of free water.

During 48 hr of observation, October–December, the speed of movement by the flock while feeding varied considerably from day to day and also with time of day. Since some areas were visited almost daily, it is quite obvious that the flock was not over-exploiting the food resources on any one visit. During early morning feeding, the flock appeared restless and moved at a rate of about 1.5 mph while calling almost constantly. During late morning and afternoon, movement was very slow or the flock remained more or less stationary, often for as long as 2 hr. During this period the flock fed quietly. Movements during feeding were carried out in either leapfrog fashion or by simple advance with all members simultaneously moving in one direction. In the former case, some jays were always on the ground while others passed overhead. Both types of feeding flights were performed below tree top level, and the birds seldom moved more than one-fourth mile in any one flight. On some days portions of the flock did not follow the group, but split off into a second foraging flock. No more than two of these groups were ever observed, and they seldom remained separated for more than half a day. At times the flock followed a rigid, predictable pattern of movement. For example, in early November 1969, the flock gathered at the very same location at 08:30 (± 10 min) on eight consecutive days.

On occasion the entire flock flew up into the tree tops in response to loud calling by a few individuals. While sitting high in the trees most of the flock joined in the chorus with loud sharp *kraws*. Some birds then flew out from the trees, swiftly through the nearby trees, then landed, and another group flew off. Within a few minutes most individuals were in the air, calling loudly. This behavior almost always led to long distance movements of the flock to a new feeding area or to their watering area. These longer flights usually took the flock over large open meadows where the familiar rolling and swirling movements were seen. The flock generally moved over these meadows at a height of 80–100 ft, with members in the front of the group turning back to the point of departure in the forest or woodland, being replaced at the head of the aggregate by individuals near the middle of the flock. These individuals would then turn back, while a new group assumed the lead. Birds that turned back often changed direction again when they reached the rear of the flock. Loud calling always accompanied these flights. When flights of this nature commenced, the flock relocated 1–2 miles from its point of departure. Occasionally the number of birds heading back to the departure area was so large that the entire flock returned to the starting point in the forest or woodland. On at least one occasion, three false starts occurred, with the flock returning each time to the starting area. These rolling flights were never observed over woodland or forest. On other occasions, the flock flew over meadows in a straight line.

At any time while feeding in the forest and woodland, about 40 per cent of the flock foraged on the ground by probing for insects and/or pine seeds. The birds walked along, stopping at frequent intervals to cock their heads, and then pushed the bill into the substrate. On occasion birds pushed the pine needle litter in front of them with their bills, exposing the bare ground. Piñon Jays pushed empty cones ahead with their bills or grasped the cones in their bills, throwing them aside with strong lateral movements of the head. When a seed was located, it was either swallowed entire and held in the throat or cracked open and eaten. Birds flew up to a branch or stump to open the seed in typical jay fashion. Thus, there was a great deal of movement from ground to tree and back during the initial feeding period each morning.

In addition, a larger number of birds were observed foraging off the ground. One preferred site was on dead, fallen trees with loose bark. The birds searched carefully for insects

and cached seeds on these downed trees and hammered vigorously to flake away the bark. Individuals feeding in this manner often clung to branches and trunks. The loud hammering was reminiscent of woodpecker activity. Birds also commonly foraged for food in crevices in the bark of living trees. Another popular feeding site was the tips of branches of ponderosa pine where the tender new growth occurred. These tips were broken off and carried to a larger branch where they were thoroughly dismembered. Still other jays spent considerable time clinging to pine cones in typical chickadee and jay manner, working for as long as 5 min to extract a single seed. During seed extraction a number of cones and seeds often fell to the ground. On two occasions ground feeders were seen picking up whole pine seeds which had just been dislodged from a cone overhead. At no time did a bird working on a cone retrieve a seed that had fallen out of the cone.

After about 2 hr of intensive feeding in Ponderosa Pine Forest the birds no longer ate the seeds they collected, but held them in their throats and carried them to cache-sites, where they were stored for future retrieval. Hill and Wiggins (1948) noted 33, 34, and 43 ponderosa pine seeds in the throats of three Piñon Jays collected in Baja California. Cache-sites were prepared by clearing the needles and litter from a small area. Both the bill and feet were used to expose the substrate. With a slight vertical flick of the head a seed was forced into the mouth and then pushed slightly into the ground. At 21 cache-sites the number of seeds varied from 6 to 31 ($\bar{x} = 14.8$). After the seeds were deposited, the site was covered with needles, grass, and on two occasions large pine cones. Piñon Jays were observed caching food in a number of rather specific sites. If stored beneath the litter on the ground, seeds were most often placed under the canopy of a tree close to the trunk. In 14 of 21 observations of food storage near the base of a tree, food items were placed on the south side of the tree; the remaining sites were on the west or northeast sides of the tree. Regarding this selection of storage sites, it is of interest to note that after heavy snows the entire flock often foraged directly under the canopy of the pines where the snow was usually about one-half as deep as it was in the clearings. Birds probed through the snow to locate food during these periods. On one occasion we observed the flock foraging through the Ponderosa Pine Forest after a four-inch snowfall. After the flock moved on, we counted and measured the direction from the trunk of 48 probe holes made in the snow. Thirty-six or 75 per cent were on the south side of a tree under the canopy. The first areas to melt free of snow with the return of mild temperatures were adjacent to the south sides of tree trunks. Placement of food in this specific location seemingly insured access during inhospitable times. A second area used for the caching of food was the deep crevices in the bark of older ponderosa pines. Birds placed one or two pine seeds in the crevices and later searched for food in these same places when a blanket of snow hindered ground foraging.

Although retrieval of all stored seeds at a later time could not be ascertained, two interesting types of retrieval were observed during this period. On two occasions gray, first-year birds were seen watching adults cache food in crevices. In both cases, after the adult left, the first-year birds flew to the exact spot and appeared to harvest the seeds. On one other occasion a first-year bird flew to a cache-site before the adult had departed and was driven from the site immediately. A second group of observations involved Steller's Jays (*Cyanocitta stelleri*), whose winter home ranges were often inhabited by the Piñon Jay flock. The Steller's Jays did not respond aggressively to the presence of the Piñon Jays but often searched for food and fed with them. After the Piñon Jay flock moved on, Steller's Jays intently searched the crevices in bark for stored food.

Often a newly located seed was fed to the potential mate. Observations of three banded pairs suggest that pair bonds were maintained year-round, at least by some individuals. In others, this feeding may serve in pair formation. Feeding of potential mates was almost non-existent in October but showed a marked increase in frequency from mid-November through December. Potential mates were fed either at the foraging site or, more frequently, high in a tree 100–300 ft from the foraging flock. This behavior presumably served in the formation and strengthening of pair bonds and simply involved taking the seed in the bill and presenting it to a silent and almost motionless partner. Once the exchange occurred, the recipient cracked the seed open and most often appeared to eat it. After feeding, both partners often remained high in a pine tree. Although this behavior usually was performed by adult birds, gray, first-year birds also performed silent courtship feeding, indicating pair bonds were formed during their first winter.

By mid-December, courtship feeding became much more obvious and noisy. Not only were seeds passed silently, but females were seen to chase the males and beg fairly loudly for food; occasionally males begged from females. These

begging calls lasted 5–25 sec ($\bar{x}$ = 17.5 sec; n = 87). Begging birds often sounded as though they had food lodged in their throats as they gave a loud rasping *kaw*. This begging call was given from a characteristic posture. The begging bird crouched slightly, with the bill pointed upward at about a 60° angle. The partly outstretched wings were fluttered vigorously, and the tail, which usually touched the substrate, was motionless and not fanned. Members of a pair fed more closely to one another from this time on and spent more time sitting silently together in the trees. Occasionally small sticks or grasses were picked up by the male, manipulated in the bill and then presented to the partner, but these offerings were seldom received and seldom evoked any response by the potential recipient.

Thereafter the intensity of courtship varied greatly with time and place; it occurred most often from mid-morning to mid-afternoon. This coincided with the period of decreased feeding activity, and was also the warmest portion of the day. On colder days, courtship frequently did not commence until 10:30 and ceased by 14:30. In contrast, on warm sunny days courtship was observed as early as 09:00 and continued to 15:40.

Courtship behavior was performed most regularly in areas where nests had been situated in previous years. Courtship feeding calls were at least three times as intense when the flock was located on the nesting grounds. Thus, we conclude that a definite portion of the home range is used specifically for nesting purposes (fig. 1), and a recognizable change in behavior occurs when the flock enters this nesting area. This is similar to the breeding pattern of the Rook (*Corvus f. frugilegus*) (Marshall and Coombs 1957). Jensen (1926) however, did not find this to be the case in New Mexico where the Piñon Jays he studied "do not return to the same locality to breed year after year. . . ."

Throughout the non-reproductive period, the feeding flock was commonly surrounded by 4–12 sentries, as previously reported by Cary (1901). The number of sentries was fewest during early morning feeding (4–6) and greatest at mid-day (5–12). Sentinels were usually positioned at some high vantage point, sometimes exposed and sometimes deep in the foliage. They remained motionless and silent until the approach of an intruder; then the sentinel(s) nearest the approaching animal gave a loud rhythmic *krawk-kraw-krawk*, repeating it two or three times. This warning call was usually sufficient to cause the flock immediately to cease feeding and fly up into the trees. If the sentinel did not repeat the warning call, the flock resumed feeding within one or two minutes. After the sentinel(s) gave the initial warning call, it often flew down to a position 10–15 ft above the intruder where it continued calling while frantically flying from branch to branch. While perched, the sentinel often gave the threat posture described earlier: bill pointed at the intruder with head and neck feathers depressed and the neck outstretched. If this behavior persisted, up to 15 ($\bar{x}$ = 9.7; n = 19) jays approached the intruder and performed in a like manner. Stationary Great Horned Owls, Sharp-shinned Hawks (*Accipiter striatus*), Cooper's Hawks (*Accipiter cooperii*), Red-tailed Hawks (*Buteo jamaicensis*), and gray fox (*Urocyon cinereoargenteus*) were observed being mobbed in this manner. Hawks and owls that flew off during these encounters were always chased by the mobbing jays, who continually gave the loud rhythmic call. Great Horned Owls seldom flew long distances and could not evade detection. Consequently Piñon Jays often chased and scolded them for as long as 45 min. During these encounters, the main body of the flock flew 400–800 ft to a new feeding site. The sex of the sentries was not determined, but of 93 instances when sentries gave the warning call, 76 per cent were adult birds, the remainder were first-year, gray birds. During this period of the year, first-year birds seldom mobbed stuffed owls or potential predators as vigorously or for as long as did adult birds. Adult and first-year birds performing courtship feeding, by nature of their position relative to the feeding aggregate, probably often served as sentinels.

During this period the flock roosted in a variety of locations within its home range. Birds seldom, if ever, roosted where they last fed in the evening. A long flight of 1–3 miles often preceded roosting. These flights were performed at tree top level and were accompanied by a great deal of calling. As birds landed in the trees much chasing and scrambling among the branches occurred. This behavior usually lasted 8–15 min and was accompanied by a moderate amount of calling. If an intruder approached, a hawk flew over, or a Steller's Jay gave a danger call, the entire flock rose up and moved to another location. When most individuals located adequate roosting sites, however, the above interruptions caused no movement of the flock, even if a single Piñon Jay gave a loud call.

Because of the poor light at roosting time it was impossible to recognize color bands, but the flock was not uniformly distributed throughout the trees. Some large trees con-

tained as many as 15 individuals, while others contained none. Roosting birds were noticeably clumped together in groups of from two to five. This seemingly indicates that pairs and family groups roost together throughout the non-breeding season.

NESTING PERIOD

During January or early February, the behavior and make-up of the flock changed dramatically as pair formation and courtship activities sharply increased. This was first apparent because of the greater amount of time the flock spent on the preselected or traditional nesting grounds. If conditions were mild and snow was negligible or absent, the flock spent up to 40 per cent of each day on this area. In contrast, during late fall and early winter only about 20 per cent of each day was spent on the nesting area. During the nesting period the flock spent 90 per cent of its time in Ponderosa Pine Forest which included the breeding grounds (fig. 4).

Early morning foraging was performed in a manner similar to that described for late fall and winter. Birds left the roost at about 06:40 and foraged as a unit for about 1.5 hr. After this time we observed "courtship parties or chases," "spring gatherings," or "pursuit flights," as observed in other corvids (Goodwin 1951; Marshall and Coombs 1957; Hardy 1961; Brown 1964), involving as many as 12 individuals and including both adult and first-year gray birds. These groups flew rapidly through and over the trees, performing sharp turns and steep dives. A very low *cluck* was often given by the birds performing these flights. In 6 of 64 such groups observed, banded adult females led the group. Of these flights 72 per cent were observed on or adjacent to the nesting area. Flights led the groups as far as 900 ft from the feeding flock and may not only serve to stimulate individuals during courtship, but also act as an initial mechanism to separate courting birds from the feeding flock. Goodwin (1951) believes that these gatherings function "to facilitate the meeting of unpaired birds that are ready to pair." Pairs also began to move as far as 1000 ft from the feeding flock where they simply fed together, fed each other, or the male presented twigs and grasses to the female. Courtship feeding was often, but not always, preceded by the loud, rasping begging calls and posturing of the female. Individuals that continued feeding usually moved very slowly as a unit, and the pairs on the periphery managed to keep up with the feeding unit. Males occasionally picked up a twig or sprig of grass and flew up to a perch above but near the female. If the female responded by following the male, both flew from the feeding aggregate. On many occasions, however, a pair flew off from the feeding group without nesting material. Since many courting pairs were performing in a like manner, by 09:00 the feeding flock contained only 50–70 birds; many of these were gray birds that continued to feed and court as they had through the previously described period. The immature, gray birds also flew off from the feeding aggregate but not as often nor for as long an absence as the adults.

This leaving and re-entering the flock by courting birds continued for most of the day. About 2 hr before sunset the entire flock reformed and fed as a unit until roosting.

During this period the feeding nucleus was more stationary than during mid-winter but did move slowly through the forest. As spring approached, more time was spent in feeding on the ground (fig. 4) than in the foliage. At various times the feeding flock performed a unique movement seen only during this period of the year. A small group in the feeding flock began to *kraw-kraw* or *kaw* softly, and this call was then picked up by all feeders. As more birds joined in this vocalization, it increased in a crescendo, then the flock flew high above the trees and on to a new foraging site. The noise made by the flock was a resounding din and could be heard for over three-fourths of a mile. During this din all courtship behavior ceased and the courting birds flew quickly toward the moving flock, giving the call described above. As pairs courted some distance from the feeding unit, the flock was often strung out 600 ft or more during these movements. These flights were seldom more than one-half mile in distance. Once the flock alighted, the din ceased and courtship began again with pairs radiating out from the new foraging site. The time intervening between these dins and subsequent movements varied from 25 min to 2 hr ($\bar{x} = 57.4$ min; $n = 13$) and was probably determined by the amount of food available at the feeding site. In general these flights took the flock from one part of the traditional nesting grounds to another location within or near the nesting area. It is possible that the din and flight periods alternating with feeding periods serve a signal function, stimulating other pairs to the state of breeding readiness of the courting pairs. The din also serves as a focal point for regrouping the flock.

Nest building by the majority of the mature breeding birds commenced during late February to mid-March during the three years of

observation. No geographic subdivisions of the breeding pairs were evident at this time as all adult, breeding birds began work on nests in an area of about 120 acres. During this time members of the flock continued to roost together and feed as a unit for about 1.5 hr every morning, sporadically during the day, and again in the evening. Nest building was closely synchronized, resulting in a sharp decline in the number of birds comprising the foraging flock. The flock during midday consisted mostly of birds hatched the previous year (33–55 individuals) plus a few (10–15) non-nesting adults. At times the two groups were separated, and the nest builders left the sites together as one flock while the non-nesters were grouped into another flock. However, during nest building the gray bird flock was often within 1500 ft of the nest builders and was readily joined by these latter birds, especially when the loud din was given by the gray bird flock. The first nests of the year were placed 50–500 ft apart so that the loud *krawk* call (signalling a movement away from the nest-site area) could be heard and responded to by all builders. Thus, most pairs were actively engaged in nest building at the same time. A constant *near-ering* call was given and pairs could thereby detect the location of neighboring nests.

Although Sutton (1967) reports dull blue birds in breeding condition and Ligon (1971) has observed first-year females nesting, we have not. All nesting females were at least in their second year. Four first-year females collected possessed neither a brood patch nor enlarged ovaries.

During egg laying, individual pairs spent at least 35 per cent of their time in the vicinity of the nest although they foraged with the flock throughout early morning hours. Females incubated or simply sat lightly on the nest while the male was either in the area immediately surrounding the nest or off with the feeding flock. The feeding flock usually consisted of 40–55 birds during this period; it wandered moderate distances (1–3 miles) from the nesting area (but still within its prescribed home range). The flock contained first-year birds and a small group (4–7, $\bar{x} = 5.3$; $n = 13$) of non-breeding adults. As nesting adults usually synchronized their movements from the nesting area to a feeding area, there were in essence two separate feeding flocks during this period each spring.

When incubation began, the males left the females and formed a feeding flock which was sometimes joined by the first-year birds and non-breeders, but often males fed alone as a group. The nesting males periodically left to feed the females (approximately 8–15 min of each hour) and then returned to the same general area to feed. Returning males were somewhat synchronized in their movements to and from the nesting grounds, and came in groups of 6–8 individuals. The entire male flock, however, fed together for about 30 min of every hour. When females were fed, the males approached from the same direction and also left in that direction after feeding their mates. During this phase of the nesting cycle we spent 89 hr observing 33 different nests. Braly (1931) briefly described the same behavior for a Piñon Jay colony in Oregon, and Phillips et al. (1964) noted that the male feeding flock sought food for the incubating females. The males roosted as a group during this period, and spent up to 1.5 hr feeding together before the initial feeding visit of the day to the females.

This same pattern held after the eggs hatched and until the young were partly feathered. At this time males and females from several adjacent nests often fed together; the return to the nest was not synchronized in any noticeable way.

During the first 12–15 days after hatching, no more than two birds were seen attending the young at any of 26 different nests observed over a span of 43 hr. This is in marked contrast with the finding of Brown (1970) for the Mexican Jay (*Aphelocoma ultramarina*) in which up to 62 per cent of the feeding visits are made by helpers. During the last four or five days of nestling life, however, as many as seven individual adults were seen around some nests. Since many of the individuals were unbanded, their status was not ascertained. A banded female with four young in her nest was seen feeding young in a nearby nest. One unbanded male was observed feeding young in two adjacent nests. Thus, co-operative or communal feeding of nestlings clearly occurs, but our observations indicate that it did not commence until the last few days of the nestling period. This coincides with the time the young nestlings become very vocal in begging for food.

Communal feeding of nestlings is common in both the Mexican Jay (Brown 1970) and the Tufted Jay (*Cyanocorax dickeyi*) (Crossin 1967). In both species, non-breeding, year-old birds regularly fed the young. This, however, is not true of the Piñon Jay, as we have never observed a gray, first-year bird feeding nestlings. On seven occasions, adults chased yearlings when they approached nests.

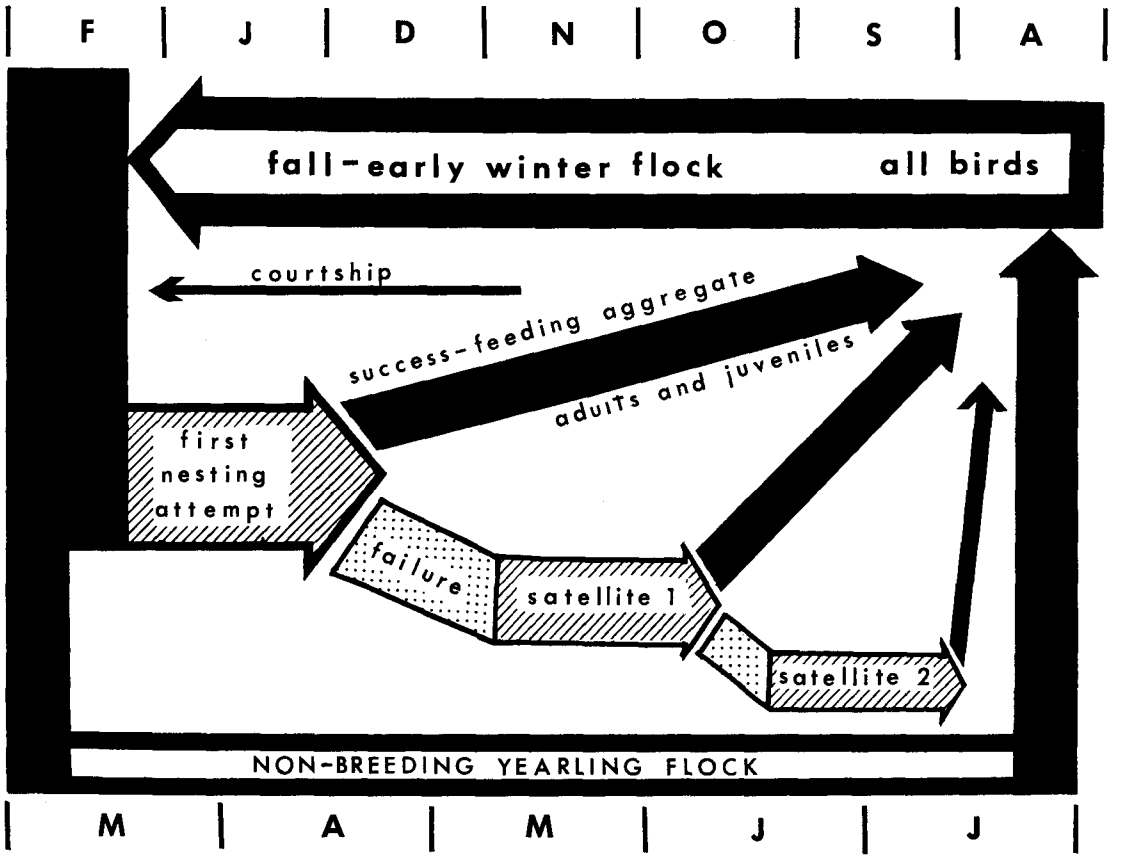

FIGURE 5. A schematic representation of the events in the yearly flocking cycle of the Piñon Jay when piñon pine nuts are in adequate supply. Black arrows and lines indicate flocking. Arrows pointing left to right indicate activities performed from March through July; those pointing right to left indicate activities between August and February. Dotted areas indicate nest failure; oblique lines, nesting attempts.

FLEDGLING AND POST-REPRODUCTIVE PERIOD

Because the initiation of nesting was reasonably well synchronized, most eggs hatched at about the same time, and young from different nests within the colony left the nest within a relatively short span of time. Never, unless an unusual circumstance occurred, did more than six days elapse between fledging at different nests. Examples of this included a pair that moved into a colony after egg laying or incubation was underway, or a pair that took an exceptionally long time to build a nest. Both occurred as single isolated events. Upon leaving the nest, young and parents formed tightly knit feeding aggregates that remained in the general area of the nests 8–12 days. The young are poor fliers at fledging and spent most of their time sitting silently in the lower portions of the tree canopy or in shrubs. The groups seldom ranged more than ¼ mile from the nesting area during this period. In late April the feeding aggregates consisted of 25–50 young and adults, depending on the size and nesting success of the breeding colony. Pairs not successful in their first nesting attempt formed a second nesting colony which ranged in size from 3–12 nests; rarely did a pair nest alone. These satellite colonies (fig. 1) were scattered up to ¾ mile in all directions from the initial nesting location, and young from them were fledged well into July. We suspect that pairs which fail in the second nesting attempt may try a third time because these satellite colonies were staggered in time and became progressively smaller as summer progressed. Jensen (1923) also noted that large colonies were found only in early spring in New Mexico. The net effect of this renesting in smaller colonies was that by early summer the previous winter's single flock became divided into five or six smaller feeding aggregates, each consisting of a number of family units. Each feeding aggregate was spatially independent of the others (fig. 5). Ligon (1971) observed this same pattern for Piñon Jays in New Mexico.

Immediately after fledging, the young from

a nest stayed very close to one another and begged loudly for food upon approach of an adult bird. The begging call was often given when other young were heard begging, even when no adult was nearby. One bird was captured during its second day out of the nest and moved about 600 ft from the periphery of the feeding aggregate. This fledgling sat quietly in the foliage until young in the aggregate were heard begging. The displaced bird then hopped and weakly flew directly back into the feeding aggregate, indicating that the loud begging calls serve as an attractant for the young. Although young were fed principally by the parent, other adults helped. Because we were not able to band all adult birds, it was impossible to determine if these adults were parents of other young in the aggregate or simply non-breeding birds or unsuccessful nesters. However, the following observations suggest that co-operative feeding was performed to some extent by all of the above mentioned groups. On 8 May 1969, two days after young from five broods left the nest, one unbanded adult bird fed banded young from three different nests (while young from two other nests simultaneously begged from this bird). On the same day, a banded adult from one of the five nests was observed feeding banded young from two different nests. On 10 May a banded female, whose nest had been destroyed and whose young were lost on 5 May, was observed feeding fledglings. Thus, there was indiscriminate feeding of the young by the parents from the colony and also by other adults. However, these few examples of indiscriminate feeding of the young suggest that parents play a much more substantial role in the Piñon Jay than in the Mexican Jay whose fledglings may receive more than 74 per cent of their food from other members of the flock (Brown 1970).

In feeding aggregates where young fledged early in the season, there were few "extra" adults or potential helpers in evidence, but in later satellite colonies the proportion of adults to young increased twofold. Thus, some adults that were unsuccessful in their first and/or second nesting attempts appear to have assumed a parental role for the young of other birds.

At this time gray, yearling birds still formed a tightly knit non-breeding flock (fig. 5). This flock often occupied the same areas used by the feeding aggregates, but these gray birds were never seen to feed young. On five occasions gray birds were driven from the vicinity of the newly fledged young by an adult bird. However, on three occasions fledglings begged from gray birds. Thus, our data are inconclusive on this point. After a time, gray birds usually moved off by themselves. Often four to eight dark blue adults were associated with a flock of gray birds and left the feeding aggregate with them. During late April and May the gray birds began molting into adult plumage so that by late August they could not be distinguished from adults.

Within the feeding aggregate, parental duties were divided between the two parents and showed some variation as the young became more self-sustaining. During most of the day, throughout the early sedentary period, the young sat quietly in the trees or shrubs with a number of adults nearby. Some of these adults were conspicuously posted around the periphery of the aggregate and very quickly gave the rhythmic *krawk-kraw-krawk* call at the approach of an intruder. These birds and the sentinels described earlier behaved similarly. Other adults remained partly concealed in the foliage and much closer to the fledglings. Another group of adults was usually off feeding at a distance of up to ½ mile from the aggregate. Their return was usually synchronous and from the same direction, indicating that they had fed together. The returning adults often elicited from the young a harsh squawk which apparently functioned to signal their location. The adults, with food, stealthily approached the young, who swarmed around them and begged frantically with fluttering wings. The posturing and vocalization performed by the young were very similar to those performed by courting and incubating females. The adults shook their heads from side to side to regurgitate food which was then passed directly into the throat of the begging young. One or two young were fed by each adult before it again violently shook its head to regurgitate more food. The young often crowded the adults to the point of pushing them off the branch, so that they had to move ahead of the begging young in order to have room to swing their heads. In their attempts to procure food, young begging birds were seen landing on the backs of feeding adults. The begging squawks were given throughout the entire process. After feeding the young, the adult bill-wiped, as did the young birds. The feeder usually took a position in the aggregate, and a different group of adults flew off to search for food. In early morning and evening hours the adults fed much closer to the young, and the young were fed about once in every 40 min, whereas during mid-day the interval between feedings was 50–95 min ($\bar{x} = 68.7$; $n = 17$).

By the eighth day after leaving the nest,

young were able to search for food. They often succeeded in capturing insects that they stirred up while foraging through the grass. The young also probed into the soft substrate and appeared to capture and eat insects and soft plant materials found in this manner. Family groups usually stayed close together during ground foraging. Occasionally young tried to take food from a nest mate, and even begged from it, employing the same behavior as used to obtain food from the adults.

About 20 days after leaving the nest, communal feeding of the young declined drastically to the point of virtual nonexistence. Young begged primarily from their parents who, except during early morning hours, continued to feed them, but at a much reduced rate. On one occasion banded fledglings from three different nests were observed in one tree; each group of young sat close together and begged for food only when their parent(s) entered the tree. On another occasion two birds from different nests sat quietly together until an adult appeared. One young bird begged loudly and was fed while the other continued to sit quietly nearby and was not fed. By one month after leaving the nest the young were proficient at ground foraging and picking insects off foliage and out of crevices. However, the adults continued to feed them regurgitated seeds and insects throughout this period. During the summer the adults often captured flying insects by "hawking" them from high, exposed perches. The insects were almost always swallowed before being fed to the young.

Different feeding aggregates of the same flock came in contact with one another on many occasions and sometimes foraged through an area together, but the adults and young of each group did not appear to interact, and the groups separated with no noticeable mixing of individuals. The adults were responsible for the direction and rate of movement of the feeding flock; each family unit moved as a sub-group, following the calls of the parents. If one of the young did not follow, an adult flew back and called loudly with a sharp *krawk* to attract it. This particular behavior was observed on nine different occasions as feeding aggregates moved about the home range. These feeding aggregates spent all of their time in the woodland and forest (fig. 4).

By mid-August most adults stopped feeding young, and when begging behavior was directed at them, the young were driven off. This was commonly accomplished by hunching over slightly, pointing the bill and making a short, rapid lunge at the young bird. Adults often silently watched young birds forage during this time. By the time young were completely independent, their bills, which are dark gray spotted with horn or cream color at hatching, had become entirely black.

In late July and early August of 1968 and 1969, the piñon nuts ripened, and the feeding aggregates moved up the slopes of the cinderhills to the Piñon–Juniper Woodland. Here there was intense foraging activity throughout the day, as adults broke open cones, extracted the seeds, and carried them down into the Ponderosa Pine Forest where they were stored. The cones at this time are still green, with the scales tightly closed and covered with resin. Jays removed seeds from cones still affixed to branches when a suitable perch was available, or they removed the cones from the branches and carried them to stable perches where they were vigorously hammered open. They systematically extracted seeds, until the cone was completely torn up and all seeds removed. One bird would remove all seeds from at least one cone, holding the unhulled seeds in its throat, before flying down to the Ponderosa Pine Forest to cache them. A male and female collected at this time had 27 and 19 unhulled piñon seeds in their throats. The bills of both birds were coated with the sticky yellow resin from the green piñon cones.

Although Turček and Kelso (1968), in their extensive review of this phenomenon in corvids, find little direct evidence that transportation and storage of seeds occur in the Piñon Jay, our observations show that an intensive effort is made each summer and fall to harvest, transport, and cache piñon seeds. This energy-consuming event occurs at a time in the jay's yearly cycle when no other drastic energy demands are being made on the bird. The young are either independent or nearly so, and the postnuptial molt is almost completed in most adult birds so that nearly full energy can be devoted to this task. Although the European Nutcracker (*Nucifraga caryocatactes*) (Reimers 1958) and the Clark's Nutcracker (*Nucifraga columbiana*) (pers. observ.) may carry seeds long distances, most jays do not do so. The flock of Piñon Jays that we observed carried seeds no more than ⅔ of a mile from the source. The area of storage corresponded closely to the traditional breeding area and loosely to the area where later satellite colonies formed. This indicates a strong reliance on piñon seeds for reproductive energy as has been pointed out by Ligon (1971). The caching of ponderosa pine seeds during fall and early winter, in contrast, is not confined to the breeding grounds, but occurs throughout the home range. Also, the ponderosa pine seed

crop was not completely harvested on any one visit to an area, so that the flock returned to the same area innumerable times to feed on and cache seeds.

The sites at which seeds were stored were quite specific, and this in turn probably made for an efficient and speedy recovery. Nutcrackers have been reported to go to specific sites and immediately recover seeds, apparently by using vision and memory (see Turček and Kelso 1968). The Piñon Jay merely must search the warmer, south sides of trees, and in most cases the snow-free areas, immediately after a storm to find cached seeds. Images of these sites could well become fixed, in a manner similar to that of the search image discussed by Tinbergen (1960).

Our observations indicate that cached seeds are recovered, eaten, and used for courtship purposes during most periods of the year. In all probability they are fed to and obtained by the incubating and brooding females. Observations not yet concluded show that nestlings and fledglings are fed cached seeds, but these seeds do not make up the major portion of their food.

Few aggressive encounters were observed between blue adults over possession of the cones, but young birds frequently attempted to take cones from each other. Young birds were observed extracting seeds, but they ate them rather than carrying them off to be stored. The harvesting of piñon nuts lasted at least 15 days in 1968 and 22 days in 1969.

After harvesting the piñon seed crop, which attracted most, if not all, feeding aggregates of the study flock to one centrally located Piñon–Juniper Woodland, the flock remained essentially intact and foraged as a unit (fig. 5). Family groups were still weakly discernible, and two or three nestmates were often seen foraging close together and moving as a group during longer flights of the flock.

In the fall of 1970, however, piñon pines within the home range of the study flock produced almost no cones. In 1967, 1968, and 1969 abundant cones were observed on these same trees. Consequently, in the fall of 1970 the feeding aggregates did not converge on the Piñon–Juniper Woodland but roamed widely, both on and off the home range. One group of 24 Piñon Jays was seen with Clark's Nutcrackers at treeline (11,500 ft) on the San Francisco Peaks harvesting limber pine (*Pinus flexilis*) seeds. We had not previously seen the Piñon Jay at these elevations, although we spent over 60 hr observing birds there. U. S. Forest Service personnel also reported Piñon Jays in areas where they had not previously been seen. It is possible that individuals of different flocks intermix during these periods of food shortage, and new flocks are formed and previous ones disbanded. At this time data are inconclusive on this point.

DISCUSSION

As pointed out by Emlen (1952) and others, aggregation of birds into flocks results from positive social forces of attraction, while the limitations on aggregations, such as flock size and crowding, occur because of negative social forces that impose certain restrictions on the individuals. In species such as the Piñon Jay that maintain large flocks throughout most of the year, the positive social forces appear to far outweigh the forces which tend to space out the individuals.

The cycle of flocking (fig. 5) shows that the flock is maintained in a variety of forms throughout the year, such as a large late-summer and winter flock, a non-breeding flock of first-year birds, a number of feeding aggregates made up of young and adults, and definite colonies during the nesting season. Thus, the advantages received are certainly numerous, complex, and variable, depending on the role of the individual within the flock (i.e., breeding adult, or non-breeding sub-adult) and on season of the year. But in all cases a high degree of sociality is maintained. In order for this to occur, a number of behavioral mechanisms must be employed to avoid continual aggressive interactions which would consume energy and therefore lower the overall efficiency of each individual. The presence of a social hierarchy, maintenance of individual distance (Condor 1949), and a well developed set of appeasement postures would all tend to reduce conflicts and suppress aggressive tendencies between individuals. Since the flock is largest during the non-breeding season, the integrated social scheme must be most highly developed during this period as there is a much greater probability of interacting with other individuals because of the rapid movement, shuffling, and mixing of individuals during foraging. All attempts to measure the individual distance between birds during this period revealed that no such phenomenon is readily determined in this species. At any point in time while the birds were foraging, we roughly estimated that less than five per cent of the flock was performing acts associated with conflicts. Most often these acts involved at least one gray bird and occurred when one individual had located a source of food, thus attracting other birds to the site.

At the salt block, mentioned earlier, no aggressive actions were observed although the birds were actually touching one another.

Since aggressive tendencies are so seldom overtly expressed, one could expect appeasement postures to be commonly observed. This was not the case, however, as the single behavioral pattern which we conclude to have the effect of dampening aggression was performed sparingly. This act, which consisted of raising the bill and exposing the white throat patch to another bird directly in front of the performer, was most often seen when three to five birds lit close to one another. Immediately thereafter some of the birds raised their bills. Although gray, first-year birds also have a white throat patch, it does not contrast with the gray plumage as markedly as it does with the blue plumage of adults. This may, in part, account for the greater number of encounters involving gray birds. The appeasement posture obviously could not be performed during intense foraging and feeding periods when the bird is pointing the bill downward as it searches for or procures food. This may well account for the fact that most aggressive encounters occurred during foraging and at food sites. In this manner the stronger and/or more aggressive birds are insured ample food while less aggressive birds may have difficulty procuring enough food when it is in short supply. This could act to insure the survival of the strongest individuals during harsh times. Thus, within the framework of high sociality, natural selection can act in this manner to select for the hardiest individuals.

Because of the rapid movement of the flock and the fact that not all birds were banded, recognition of a specific type of social or dominance hierarchy was difficult. Older birds, however, did play a major role in determining the movements of the flock. Long and short flights were always initiated by a group of from four to six blue birds. Observations on a flock of 70 birds that visited a local feeding station daily strongly suggest that the same birds appeared at the station in the same sequence. For example, an adult female (L red × R red) was always one of the first 10 birds into the feeders. However, these scattered observations are only suggestive and much more field work will be needed to describe in detail the social integration of the flock.

If aggregations of Piñon Jays, by nature of their groupings, receive benefit not accrued by solitary individuals, then natural selection should operate to insure the unity or maintenance of the group. Utilization of a well differentiated and recognized home range during most years (fig. 1) allows each individual to become familiar with the terrain so that birds separated from the flock can locate it with ease. The general noisiness and restlessness of the flock also serve as cues in locating and remaining within the flock.

The flock under study had a home range which shared a common northern and southern border with those of two other flocks of Piñon Jays. During 1968 and 1969 these borders were seldom crossed, and we did not observe banded birds in either of the other flocks. One flock was observed for a period of 14 hr on six different days, and the other for 7 hr on two days. We have no evidence of mixing or exchange of individuals between these flocks. In addition to the lack of observations of banded birds associating with neighboring flocks, two other lines of evidence support this surprising lack of exchange. First, when six hand-raised birds were marked and released within the flock, they made no attempt to integrate with it and returned to the cage-site (which was within the home range) where they remained for over two weeks even though the flock was often nearby. Thereafter, these birds were never observed in the flock. Second, in November and December of 1969, 20 adults from a second flock were captured at a local feeding station. All 20 adults were marked with color bands and backtags. Eighteen of these birds were transported 11 air miles from the capture site and released on the home range of the study flock. Within two weeks 16 of these birds had returned to their original flock. These 16 birds had to leave the home range of the study flock and pass through the home range of another flock before entering their original home range. Two birds transported 21 miles from the local flock returned to it in less than 48 hr. These birds may have passed through the home ranges of three different flocks on their return flight. It was not determined if the released birds actively avoided mixing, or if the resident flocks actively excluded them. But in either case the circumstantial evidence indicates that the jay flock is a tightly knit, integrated unit, using a well defined area in most years. Active defense of these home ranges could not be ascertained, but on one occasion two flocks foraged within 100 ft of each other and a few birds may have mingled with the "wrong" flock. However, both flocks left the area in opposite directions at a loud signal from a member of their respective flocks. Brown (1963) observed that the highly gregarious Mexican Jay maintains a well defined territory that it may actively defend from conspecifics, and Crossin (1967) noted that the

social Tufted Jay maintained a well defined home range.

The benefits obtained by individuals in the flock are difficult to assess because of total lack of data on Piñon Jays living singly. The vagaries and spottiness of the food supply have often been used to explain flocking and also nomadism in other species, as foraging in a tightly knit flock improves efficiency in exploiting a local food supply (Rand 1954; Crook 1965). The piñon pine and ponderosa pine are unpredictable in terms of developing cones and seeds. Recent observations of the flock leaving the home range when the piñon pine cone crop fails indicate that these home ranges are important in providing a year-round source of food. Failure of the piñon pines to form seeds is often a localized phenomenon, and thus the flock or portions thereof may have to travel from one area where the cone crop failed to another where cones were produced. Cones and seeds are produced only during a short period of time in late summer and must be taken at that time, or squirrels and the Clark's Nutcracker will most likely take a major portion of them. Movements of our flock suggest a very systematic program of exploiting food. The caching of piñon nuts, already discussed, is an example of this systematic program, but a more subtle program is also evident. Within the prescribed home range, the flock can presumably locate all requisites for survival and reproduction without interference, or such an area would not exist. The flock remains virtually intact during the non-breeding season in years of adequate food production, and may visit some areas of the home range almost daily. Thus, all food items are not harvested in any one visit. If such were the case, the boundaries of the home range would be constantly changing as a foodless area could not efficiently be visited or defended during the harsher portions of the year when the birds forage most of the day. The maintenance of the home range depends on visits to it, and during these visits it would be more economical to find food at the sites. Periodic visits to the same area may also indicate a phenological pattern of emergence of different food types. For example, the densities of grasshoppers and beetles may change dramatically over a period of time; thus different but usable food items may appear at different times. However, few insects are taken during the harsher periods of the year, and pine seeds make up the major portion of the birds' diet. The maturation of ponderosa pine seeds occurs during a rather short period; thus it appears that the flock does not return to these same areas to harvest foods that become available at different periods of time.

Another benefit derived from flocking is added protection from potential predators because the sentry system established around the periphery of the flock allows individuals in the feeding flock to concentrate their activities on locating food. "Group alertness," as stressed by Moynihan (1962), may also be important.

It is of interest to note the timing of various events in the yearly cycle and the behavior of the flock or individuals during these different periods. During various portions of the year the large "main flock" was either partitioned into smaller segments or divided up into pairs. In all cases, we assume that natural selection is operating to establish the most efficient and economical social system. During courtship adults actively left the areas where the main body of the flock foraged, and courted in areas where only other courting birds were present. Interruptions during this critical phase of reproduction were therefore reduced to a minimum and pairs were not involved in the social activities of birds not in breeding condition. During this period, intra-pair communication is probably more important in insuring reproductive success than is intra-flock association. The reorganization of the flock for feeding and roosting purposes supports the assumptions that feeding efficiency and protection are best achieved in a flocking situation.

The yearling flock, containing mostly birds of about one year of age, is at least partly separated from the older birds performing various reproductive activities. These yearling birds spend the majority of their time foraging about on the home range, the boundaries of which they most likely learned during the fall and early winter months. These gray birds do perform courtship feeding, indicating that pair bonds may initially be formed in an environment free of potentially competing adults. The smaller size of this flock would also suggest a less complex social hierarchy, which may in effect act as a training ground for what is to come once the entire flock is reconstituted in the fall.

Hardy (1961) and Brown (1963) have noted that prolonged age dimorphism in bill color and other somatic characters are closely associated with some species of jays that show a high degree of socialization and delayed or retarded maturation. The former is not the case in the Piñon Jay because externally the bill is essentially adult-like by 16 weeks postfledging. However, the gray, sub-adult plu-

mage may well serve the same function. Thus, recognition of first-year birds is simplified in a social environment often crowded with restless and ever moving individuals. The almost complete lack of breeding by first-year birds does indicate that sexual maturation is retarded, but the reasons for this are not easily understood. In the Mexican Jay (Brown 1970) and Tufted Jay (Crossin 1967) first-year birds act as helpers at the nest, but such is not the general rule in Piñon Jays; their contribution to the continuity of the flock in this regard is minimal at best. If food supplies are limited or numbers of adults high, only a portion of the flock may be able to utilize the extra energy needed for reproduction. This could be especially true in light of the known sporadic piñon pine seed production. This hypothesis is substantiated by Sutton's (1967) report of non-colonial, gray birds breeding in Oklahoma and Ligon's (1971) report of two first-year females with brood patches when piñon pine seeds were abundant. Another hypothetical possibility is that because of the large number of birds in the flock and the high degree of sociality, a longer period of learning is necessary before total integration into the flock for breeding purposes can occur.

The feeding aggregates may serve the same role as mentioned above. The groups are small (7–50 birds) and divided into two easily recognized age classes, young of the year and adults. The size of the group may help to insure in this communal feeding situation that no birds are overlooked and local movements can be carried out in an orderly fashion.

To date, the taxonomic status of the Piñon Jay has not been resolved. Studies of the type reported herein may not provide the definitive answers to such problems, because of the possibility of convergence of behavioral patterns in response to similar ecological conditions. They do, however, provide information that is invaluable in making such decisions. Hardy (1961) disagrees with Amadon's (1944) recommendation that the Piñon Jay is a New World jay because the Piñon Jay typically walks rather than hops. Hardy (1969) does not consider the Piñon Jay as a part of the "New World assemblage" because it is not a jay "by any standard except that its plumage is blue in color." All statements of the above nature are somewhat premature at present. For example, young Piñon Jays hop rather than walk for about two weeks after leaving the nest. Patterns of social behavior resemble, in part, those of both Old World corvids and New World jays.

SUMMARY

A flock of about 250 Piñon Jays, including 80 banded birds, was observed over a 2½-year period in order to gain some understanding of the annual cycle and flocking interactions of this little known species. Throughout the first two years of observation the flock maintained a well defined home range of about eight square miles containing Piñon–Juniper Woodland, Ponderosa Pine Forest and grassland. During the fall of 1970, however, the flock left this home range. This exit from the home range, in all probability, occurred because of the lack of available piñon pine seeds.

During the non-reproductive period from October through December the flock fed as a unit. Aggressive encounters between individuals were few and one appeasement behavior pattern was observed. Ponderosa pine seeds were commonly cached on the south side of trees during this period. These sites were the first free of snow after a storm. Courtship feeding by both blue, adult birds and gray, first-year birds commenced in November. Females begged for food, using postures and vocalizations very similar to those used by fledglings when begging from adults. A well developed sentinel system was evident throughout this period and played an important role in flock protection.

During January and February courting pairs separated from the flock and courted in relative isolation from the main feeding flock. During this period a special dinning call was used by most members of the flock as a cue to reassemble. Adult birds in the flock commenced nest building in late February to mid-March. The nests were all within a 230-acre traditional breeding ground that had been used for at least four years. In any one year the nests were dispersed over about 120 acres. No helpers were observed building nests. During this and subsequent nesting activities the first-year, gray birds remained together as a flock within the home range but did not nest. Pairs that failed in their first nesting attempt in the large colony formed smaller satellite colonies for their second nesting attempts. During the incubation and brooding periods nesting females were fed by their mates. Nestlings were fed only by their parents until about six days old, at which time helpers also brought food to the young. After fledging, adults and young from nearby nests formed tightly knit feeding aggregates that maintained their integrity until late summer. Communal feeding of young was common in these aggregates. In late summer all feeding aggregates gathered

on the piñon pine-laden slopes within the home range to gather and cache piñon seeds when available. Most caches were established in the traditional breeding grounds, indicating a strong reliance on piñon seeds for reproductive energy.

Although the flock was maintained in a variety of forms throughout the year, a high degree of sociality was maintained. As expected, aggressive encounters were not numerous and an "individual distance" could not be detected. The individuals of the flocks under study did not mingle with birds of other flocks, and returned to their own flock even when transported 21 miles from it. After the separation of the breeding adults from the nonbreeding first-year birds, it was possible that the less complex and competitive nature of the more homogeneous sub-adult group allowed for the development of a highly organized social scheme.

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