

## FLOCKING ASSOCIATES OF THE PIÑON JAY

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THE Piñon Jay (*Gymnorhinus cyanocephalus*) is a noisy, restless bird that normally forms large flocks. Our investigations of the annual flocking cycle of this corvid (Balda and Bateman, 1971) showed that several other species regularly joined and foraged with flocks of Piñon Jays.

In most interspecific flocks of the North Temperate Region reported on to date (Odum, 1942; Wing, 1941; Austin and Smith, in press; and the extensive review by Morse, 1970) the species involved are mainly insectivorous, flocks form primarily in the fall or winter, and the "flock leaders" or "nuclear species" are not present in overwhelming densities compared to the associate species. By contrast, this report deals with five associate species that join relatively large flocks of Piñon Jays: Hairy Woodpecker (*Dendrocopos villosus*), Downy Woodpecker (*Dendrocopos pubescens*), Red-shafted Flicker (*Colaptes cafer*), Clark's Nutcracker (*Nucifraga columbiana*), and Starling (*Sturnus vulgaris*). The Piñon Jay flock is maintained in a number of forms throughout the year, thus permitting interspecific association the year around. The main foods of the Piñon Jay during the fall and winter months when attendant species are most numerous are seeds of ponderosa (*Pinus ponderosa*) and piñon (*P. edulis*) pine, and occasional arthropods (pers. observ.).

The efficient procurement of food has often been used as at least a partial explanation for flocking (Miller, 1921; Rand, 1954; Short, 1961; Morse, 1970). Our observations were made on two Piñon Jay flocks, one on its undisturbed home range and the other when it visited a local feeding station where food was diverse and super-abundant. Comparisons were made of the foraging and agonistic behavior of the jays and associates in both situations.

### STUDY AREAS AND PROCEDURES

We studied intensively a flock of about 250 Piñon Jays on a home range of eight square miles located 10 miles NE of Flagstaff, Arizona for over 480 hours from February 1968 through January 1971. Movements, foraging sites (ground, trunk or branch, tip of foliage), and intra- and inter-specific social interaction were recorded. At periodic intervals foraging sites were recorded by counting all birds foraging at each site. Six hundred and forty-nine counts of the entire flock were made in this way. Aggressive encounters, either "supplantings" (overt chases) or "displacings" (retreats) were recorded (after Willis, 1966). We also noted reactions to potential predators and stuffed Great Horned Owls (*Bubo virginianus*).

The third author has a 0.25-acre feeding station which was visited almost daily by a flock of about 70 Piñon Jays for the past five years. On some fall and winter days the flock visited the station up to four times daily; during spring and summer groups of young and adults often spent hours at the station. A number of different foods including

TABLE 1

FORAGING LOCATIONS OF MEMBERS OF THE LARGE PIÑON JAY FLOCK THROUGHOUT THE YEAR (IN PER CENT)

Foraging Location	Jan., Feb., March	April, May, June	July, Aug., Sept.	Oct., Nov., Dec.
Ground	40.0	59.4	48.9	39.7
Foliage	31.8	23.3	42.1	35.6
Crevices	29.1	12.8	4.1	24.7
Hawking In Air	0.0	4.4	4.9	0.0
Total Number of Counts Made	213	172	116	148

mealworms, sunflower seeds, Spanish peanuts, commercial pigeon grain, bacon grease-bread crumb-popcorn mix, white millet, piñon pine seeds, raisins, and suet were always available at the feeding station. Qualitative notes were kept concerning the behavior and aggressive interactions of the Piñon Jays and four of the associates. The Clark's Nutcracker did not visit the feeding station.

## FLOCKING CYCLE OF THE PIÑON JAY

Descriptions of interspecific flocks often include a designation of one or more species as nuclear species without adequately describing the movements and behavior patterns of these important species in mixed flocks. We have described the flocking cycle of the Piñon Jay elsewhere (Balda and Bateman, 1971). Here we will only summarize and enlarge on behavior patterns essential to understanding the role of Piñon Jays as a nuclear species in mixed flocks.

*Fall and early winter.*—During this period blue adults and gray first-year birds formed a loosely organized flock which foraged primarily in ponderosa pine forest. During early morning feeding the flock moved at an average rate of about one mile per hour. Short flights below tree-top level advanced the birds in either leapfrog fashion or as a broad front with all members simultaneously moving in one direction. Longer flights taken over large meadows often consisted of rolling and swirling movements and were accompanied by loud calling of the flock members. Flocks moved up to 13 miles per day while foraging. In the forest some of the flock walked on the ground, either probing for insects and/or pine seeds or caching pine seeds, while other members of the flock foraged off the ground. Some of these gleaned in the foliage, hammered open pine cones to extract seeds or tore out the tender new growth at the tips of the branches. The rest of the birds picked food items out of crevices on the trunks and branches, or hammered vigorously to flake bark to

TABLE 2  
NUMBER OF INDIVIDUALS AND FREQUENCY OF OCCURRENCE OF ATTENDANT SPECIES WITH  
THE PIÑON JAY FLOCK

	Jan., Feb., March n = 49*	April, May, June n = 77	July, Aug., Sept. n = 29	Oct., Nov., Dec. n = 64
Hairy Woodpecker				
Average Number (when present)	5(2-7)**	1(1)	0	4(1-7)
Frequency of Association (%)	100***	14	0	88
Downy Woodpecker				
Average Number	2(1-3)	1(1)	0	1(1-2)
Frequency of Association	80	6	0	42
Red-shafted Flicker				
Average Number	6(4-9)	5(3-7)	2(1-4)	5(3-9)
Frequency of Association	100	71	62	81
Clark's Nutcracker				
Average Number	1(1-2)	2(1-3)	9(6-15)	7(4-12)
Frequency of Association	12	16	45	67
Starling				
Average Number	7(3-14)	9(5-16)	0	4(2-7)
Frequency of Association	39	74	0	28

\* Number of visits.

\*\* Range.

\*\*\* Per cent of visits when associates were present.

extract food (Table 1). All five associate species foraged with the large Piñon Jay flock at this time (Table 2).

During this period, the feeding station was visited from one to four times daily by a flock of 70 Piñon Jays. While at the station the birds fed on piñon seeds, bacon grease-bread crumb-popcorn mix, peanuts, sunflower seeds, suet, and mixed small grains in that order of preference.

*Winter and early spring.*—During courtship which commenced in mid-December adult blue birds radiated out in pairs from the feeding flock leaving the gray first-year birds plus a few blue birds to forage as a unit. The foraging flock varied in size from 35 to 70 birds. The foraging birds spent about equal

time on the ground and in the foliage. The birds feeding at arboreal sites divided their activities almost equally between foliage gleaning and cone feeding, and crevice picking and bark flaking. The entire flock reassembled periodically and moved to a new feeding location at a loud rapidly repeated *krawing* signal given by most individuals in the feeding flock. The resultant din could be heard for over three-quarters of a mile. During the nest building period the flock fed as a unit in the morning and evening. However, small groups of 4–12 birds often formed autonomous feeding units. Throughout the incubation period the main flock was divided into incubating females, a flock of adult males seeking and bringing food to the females and a flock of gray yearling birds. This latter subunit foraged quietly and moved rather long distances per flight.

When nest building began the visits of the smaller flock to the feeding station diminished to one each morning and evening. Small groups of jays, however, visited the station throughout the day. Later, males visited the feeding station regularly.

*Late spring and summer.*—After the young fledged, family groups of adults and juveniles foraged together as a unit. Adults failing in their first nesting attempt formed smaller nesting colonies and subsequent family-group feeding flocks. By late July the single winter flock was divided into a flock of year-old birds that did not breed, and five or six independent feeding groups. In late July or early August these flocks moved into the piñon-juniper woodland, where the birds opened piñon pine cones, extracted seeds and carried them into the ponderosa pine forest where they were cached. From this time on the birds remained together as a large flock.

#### ANTI-PREDATOR BEHAVIOR

Protection from predators is often described as a benefit of inter- and intra-specific flocking (see Morse, 1970 for discussion). Piñon Jays have two behavioral mechanisms which can be termed anti-predator behavior. These are in addition to the protection afforded the birds by their mere presence in a flock (Allee, 1938; Tinbergen, 1953).

*Sentinels.*—Throughout the year each subflock (feeding group; gray yearling flock) and the entire flock when assembled was commonly surrounded by sentries as reported by Cary (1901). The number of sentries was rather constant around feeding aggregates and the yearling flock (3–5 birds) but varied greatly (3–12 birds) around the large feeding flock that existed during the non-reproductive period. Sentinels were positioned at high vantage points, either exposed or concealed in foliage. At the approach of an aerial or terrestrial intruder the sentinel(s) gave a loud rhythmic *krawk-kraw-krawk* which was often repeated. On occasion, a ground-feeding bird also gave this warning

call. This call was often sufficient to cause an immediate cessation of feeding and flight of all individuals up into the trees. During these rapid ascents, birds flew in all directions and it would seemingly be difficult for a predator to focus on and capture an individual. If the warning call was not repeated the flock resumed feeding. Individuals foraging in the trees when a warning call was given simply stopped feeding and remained still. The associate species responded to the warning calls in the same manner. Even though Steller's Jays did not participate in the activities of the mixed flock they responded to the warning calls. Piñon Jays in turn responded to the *shook* call (Brown, 1964) given by the Steller's Jay at hawks or owls.

*Mobbing*.—After the rhythmic warning call was given a number of birds (3–15) including the sentinel(s) often approached the intruder, circling it if it was perched or on the ground. If flying or running the intruder was chased. During this performance the mobbing Piñon Jays called loudly, often attracting numerous other birds including Steller's Jays, Red-shafted Flickers, Grace's Warblers, Chipping Sparrows, Acorn Woodpeckers, and juncos. Hawks and owls that flew off in response to this harassment were always chased by the Piñon Jays. The Sharp-shinned Hawk (*Accipiter striatus*) and Cooper's Hawk (*Accipiter cooperii*) often evaded the jays by flying an erratic but rapid course then landing and sitting quietly in a camouflaged location. Red-tailed Hawks (*Buteo jamaicensis*) and Rough-legged Hawks (*Buteo lagopus*) usually left the area by gaining elevation rapidly and then moving off. Great Horned Owls, however, seldom flew long distances and could not evade the jays. Consequently, Piñon Jays often mobbed them for up to 45 minutes.

#### FLOCKING ASSOCIATES

The following accounts are only for the five attendant species (Moynihan, 1962) which regularly occur with the Piñon Jay (passive nuclear species, cf. Moynihan, 1962) flock at least for a portion of the year but are not important for the maintenance of the flock.

*Hairy Woodpecker*.—One to seven individuals of this species were constant members of the jay flock from late October through early March (Table 2). An occasional individual accompanied the non-breeding flock during the spring and early summer. During this woodpecker's nesting period it did not associate with the flock. Nesting alone, however, cannot explain its seasonal appearance, as it left the flock before it began courtship and did not enter the flock until well after all its nesting duties were completed. During the period of association, however, the foraging pattern of the Piñon Jay was similar to that of the Hairy Woodpecker.

During fall and winter the jays spent considerable time searching the deep

crevices of the ponderosa pine trunks, hammering and flaking bark to extract food from old dead branches and stumps, and extracting seeds from ponderosa pine cones. Whether foraging alone or with the jay flock, Hairy Woodpeckers used these same sites. Stallcup (1969) reported Hairy Woodpeckers spending 64.5 per cent of their time extracting seeds from ponderosa pine cones in Colorado. Stallcup's figures indicate that Hairy Woodpeckers spent about 83 per cent of their time foraging in the three sites listed above for the Piñon Jay. He noted that feeding on cones occurred mainly from mid-December through February, the very time these woodpeckers associate with the Piñon Jay flock in central Arizona. He reported as did Morse (1970) that the Hairy Woodpecker foraged throughout the winter in mixed flocks. Short (1961) reported the Hairy Woodpecker as a member of mixed flocks in Oaxaca, Mexico.

Hairy Woodpeckers were seen with the jay flock from sunrise to sunset and remained within the flock as it moved about in the forest and woodland. Interaction at foraging sites was minimal except at pine cones, where the jays successfully drove off the woodpeckers. Of 29 aggressive interactions observed, single jays or groups of jays were able to supplant the Hairy Woodpeckers 20 times. Nineteen of these encounters occurred at pine cones. Hairy Woodpeckers supplanted jays on 9 occasions. At other feeding sites woodpeckers of this species were always displaced by groups of seven or more jays.

During the short movements of the jay flock, the Hairy Woodpeckers always followed the Piñon Jays. The woodpeckers did not follow the flock when it made longer flights across fields, but remained in the trees at the edge of the field, calling loudly as the flock departed. Once, after the flock crossed a field one-quarter mile in width, three Hairy Woodpeckers rapidly flew around the edges of this small field to rejoin the jays. We have followed individual woodpeckers that spent four consecutive hours and traveled at least five miles with the flock.

At the feeding station, resident Hairy Woodpeckers fed alongside the Piñon Jays until the jays became too numerous at one location. Then displacement occurred and the woodpeckers perched silently in the trees until the jays left the station. The jays clearly dominated the woodpeckers; on one occasion an adult Piñon Jay took eleven peanuts, consecutively, from the bill of a Hairy Woodpecker. The woodpeckers did not come to the feeding station with the jays nor did they leave with them.

*Downy Woodpecker.*—This species associated with the jay flock during roughly the same months as did the Hairy Woodpecker (Table 2). Its foraging mode was somewhat different, however, as it spent most of its time on the trunks and branches of the ponderosa pines and on the dead trees, where it gleaned and flaked bark in search of food. Often it picked through pine

cones on the ground, but it seldom worked on cones up in the foliage. Downy Woodpeckers occur in low densities in this area; consequently, more than three individuals were never seen with the jay flock at one time. Of 14 interactions between jays and this woodpecker, the latter was displaced 12 times and supplanted twice. Seven of these interactions occurred while this woodpecker fed on some object either on the ground or a short distance from it. Most direct conflicts were avoided because the Downy Woodpecker managed to stay away from Piñon Jays when they fed close together in groups. In other respects this species acted similarly to the Hairy Woodpecker. The calls of both species evoked no noticeable reactions from the jays.

At the feeding station the Downy Woodpecker did not feed at its usual sites when jays were present. It always left the area when the jays entered the station and returned when the jays left.

*Red-shafted Flicker.*—Flickers were the most regular associates of the Piñon Jay flock. Even during their breeding season a few flickers were almost always with the non-breeding gray bird flock (Table 2). During fall, winter, and spring as many as nine individuals were in constant association with the jay flock. One individual that was specifically followed spent seven hours with the jay flock and moved about nine miles with it.

The Red-shafted Flickers spent most of their time foraging on the ground among the jays. Their soil-probing activities greatly resembled those of the Piñon Jay. During slow movements through the forest and woodland the flickers flew with the group and were never segregated at the periphery or rear of the flock. During the winter months, Red-shafted Flickers spent considerable time probing into decaying logs for immature insects. This activity strongly resembled that of the Piñon Jay when caching food in these sites. Aggressive encounters were observed when jays and flickers foraged on the ground; groups of jays were observed driving flickers from cache sites in decaying logs. The jays either pointed their bills at the flickers or flew up at them. When a single jay came in contact with a flicker ( $n = 48$ ) Piñon Jays were displaced or supplanted 46 per cent of the time, while jays dominated flickers 54 per cent of the time. When the jay flock moved over large fields some flickers often accompanied them, but others stayed behind, calling loudly as the flock departed. When sentry jays along the edges of the feeding flock gave their rhythmic *krawk-kraw-krawk*, signaling the approach of a potential predator, the flickers responded immediately by flying up into the trees in the same manner as the Piñon Jays. When the warning calls subsided, the Red-shafted Flickers returned to foraging on the ground with the jay flock. Thus, their movements between feeding sites, as well as their movements within the flock when it was stationary, were carried out in synchrony with the Piñon Jays and in a similar fashion.

During the non-breeding season the Red-shafted Flickers appeared to be paired, a male and a female often foraging near one another. On one occasion in May, a feeding group of jays moved through an area where a pair of flickers was excavating a hole. The birds stopped working, flew into the aggregate, and foraged with them for at least the next hour.

At the feeding station Red-shafted Flickers fed near the jays but did not enter or leave with them. The flicker used bill pointing and thrusting to supplant Piñon Jays when it was not badly outnumbered, however a flicker always retreated from groups of 11 or more jays.

Red-shafted Flickers are strongly attracted to Piñon Jay flocks (Table 2), and during the non-breeding season it was rare to find a solitary flicker or pair of flickers far from the jay flock. J. D. Ligon (in litt.) observed the same phenomenon in New Mexico. Short (1961) described the Red-shafted Flicker as an irregular attendant of mixed flocks in Oaxaca, Mexico. Its behavior in the vicinity of Piñon Jays appears to be quite different.

*Clark's Nutcracker*.—Nutcrackers descended the slopes of the San Francisco Peaks in late August to collect piñon seeds and carry them up the mountains to about 10,500 ft, where they were cached. During this period of seed collecting the nutcracker opened the green cones in such a manner that in poor light it was impossible for us to distinguish nutcrackers from Piñon Jays. The jays and nutcrackers worked on the piñon cones in close association, yet no aggressive interactions were noted. Johnson (1902) commented on such an association in central Utah. On one occasion a yearling Piñon Jay watched from a distance of about one meter as a Clark's Nutcracker opened a cone. At intervals spanning seven minutes the young jay fluttered its wings and begged softly while facing the nutcracker. The latter did not react to this begging. As the jay flock moved between feeding sites up to 15 nutcrackers moved with the flock. They responded to the danger *krawks* of the Piñon Jay by dropping the cones they were extracting seeds from and flying up to the tops of trees. They returned to seed collecting when the jays did. Twice the jay flock left the woodland and flew more than two miles to a watering hole, with eight Clark's Nutcrackers accompanying them. During these flights, the low throaty calls of the nutcrackers could be distinguished from the *krawks* given by the jays. The nutcrackers were always in the rear half of the flock during these flights.

During the spring and summer of 1969 from one to three nutcrackers were often with the yearling flock and also with feeding groups. The usual raucous calls given by nutcrackers during foraging and flight were not heard from these individuals. While foraging on the ground, they performed probing, insect capturing, and seed opening much as did the Piñon Jays.

*Starling*.—Beidleman and Enderson (1964) first described the association

of Starlings with a flock of Piñon Jays in Colorado. In central Arizona, from 3 to 16 Starlings were associated with the jay flock during March, April, and May, and again during October and early November. Most Starlings left the jay flock during the nesting period and again in early winter when they became rare in rural central Arizona and conversely very common in the cities. Throughout the spring and summer months Starlings nested within the home range of the Piñon Jay flock but did not associate with it.

In late winter of 1968 the Starlings were first observed with the Piñon Jay flock when the male jays were roosting as a group and the females were incubating. During this period the Starlings roosted in holes, and on three mornings they stayed in their holes until the male jays called loudly and moved out of the forest to feed for the first time. The Starlings' initial response to these calls was to look out of the holes, squawk loudly, and fly directly to the flock of feeding jays.

Late in the winter of 1969 Starlings were first noted in the Piñon Jay flock at the time courtship activities had commenced. After feeding in a very deliberate fashion with the jays on the ground for an hour in the morning, the Starlings began courting. Pairs segregated from the jay flock and courted high in the foliage and examined old woodpecker holes. The Starlings' initiation of courtship agreed closely with the beginning of the daily courtship of Piñon Jay pairs. Courting activities were noted for six to ten Starlings each morning, and indicate not only a strong attraction to the jay flock, but also a close synchronization of daily events. The synchrony may be coincidence but also suggests the Darling effect (Darling, 1938).

During foraging the Starlings walked slowly and probed for seeds and insects in the same manner as the jays. Not only was their gait similar to that of the Piñon Jay, but in short flights made between feeding sites the Starlings displayed a very similar pattern of flight. At take off, both species beat their wings rapidly, but during sustained flight strong wing beats alternate with gliding. Neither of these species undulates in flight as do most woodpeckers, as the wings are partly outstretched during the glide phase of the flight. Jensen (1926) and Wetmore (1920) have pointed out these behavioral similarities. Under cloudy conditions, or when the jays and Starlings moved through heavy foliage, it was difficult to tell them apart.

Aggressive encounters between Piñon Jays and Starlings were not common as a Starling was not easily displaced by the mere presence of a Piñon Jay. Of 51 aggressive encounters observed, the Piñon Jay supplanted or displaced the Starling 57 per cent of the time; at least five other encounters resulted in both individuals leaving the area.

At the feeding station Starlings associated with the jays from November through mid-April. During the early winter, Starlings commonly entered

TABLE 3  
SOLITARY SPECIES OCCURRING IN THE HABITATS USED BY PIÑON JAYS

Species	Mean Weights (g)
<i>Selasphorus platycercus</i>	3.4**
* <i>Colaptes cafer</i>	110.9
<i>Sphryapicus varius</i>	50.7
* <i>Dendrocopos villosus</i>	64.3
* <i>Dendrocopos pubescens</i>	27.8
<i>Tyrannus vociferans</i>	47.0
<i>Contopus sordidulus</i>	13.7
<i>Tachycineta thalassina</i>	10.6
<i>Cyanocitta stelleri</i>	113.0
<i>Parus gambeli</i>	28.2
<i>Sitta carolinensis</i>	18.1
<i>Certhia familiaris</i>	7.8
<i>Regulus calendula</i>	6.5
<i>Lanius ludovicianus</i>	47.0
<i>Dendroica auduboni</i>	12.6
<i>Dendroica graciae</i>	7.8
<i>Vireo solitarius</i>	17.0
<i>Piranga ludoviciana</i>	29.7
<i>Piranga flava</i>	37.6
<i>Chondestes grammacus</i>	26.1
<i>Spizella passerina</i>	13.2

Total Number of Species = 21

Number of Associates = 3

\* Indicates associates of Piñon Jay flocks.

\*\* Sources for weights in this table are Baldwin and Kendeigh (1938), Hartman and Brownell (1961), Miller (1955), Poole (1938), Salt (1957), Hubbard and Ligon (in litt.). Whenever possible weights were obtained from specimens in the Museum of Northern Arizona and the Northern Arizona University Museum of Vertebrates.

and departed from the station with the jay flock. However, in late winter and early spring Starlings were much more prone to stay at the station. Early on winter mornings Starlings gathered just outside of the station but would not enter until the jay flock entered. If the jays did not appear by 09:30 the Starlings left without feeding at the station. When feeding at the station, Starlings mingled with even the largest groups of Piñon Jays and were not displaced.

On two occasions during the winter of 1969, groups of Piñon Jays were seen associating with an urban flock of Starlings. On both occasions, the flocks contained about 55 Starlings and eight to ten yearling Piñon Jays. The flocks moved silently through a forested area.

TABLE 4  
GREGARIOUS SPECIES OCCURRING IN THE HABITATS USED BY PIÑON JAYS

Species	Mean Weights (g)
<i>Zenaidura macroura</i>	122.8**
<i>Melanerpes formicivorus</i>	66.0
<i>Eremophila alpestris</i>	43.0
<i>Corvus corax</i>	969.0
<i>Corvus brachyrhynchos</i>	479.0
* <i>Nucifraga columbiana</i>	142.2
<i>Psaltriparus minimus</i>	5.8
<i>Sitta pygmea</i>	9.9
<i>Turdus migratorius</i>	80.7
<i>Sialia mexicana</i>	24.6
<i>Sialia currucoides</i>	34.7
<i>Bombycilla cedrorum</i>	32.9
* <i>Sturnus vulgaris</i>	81.9
<i>Sturnella magna</i>	145.0
<i>Molothrus ater</i>	50.5
<i>Euphagus cyanocephalus</i>	64.8
<i>Hesperiphona vespertina</i>	53.6
<i>Carpodacus cassinii</i>	27.5
<i>Spinus pinus</i>	12.2
<i>Spinus psaltria</i>	10.4
<i>Junco hyemalis</i>	21.0
<i>Junco oreganus</i>	17.4
<i>Junco caniceps</i>	19.7

Total Number of Species = 23

Number of Associates = 2

\* Indicates associates of Piñon Jay flocks.

\*\* Same as Table 3.

#### DISCUSSION

Of the five species that associated with the jay flock, three are usually solitary, whereas the other two are often found in intraspecific associations (pers. observ.; Tables 3 and 4). Some of the species listed as solitary in Table 3 form intraspecific flocks at times of the year when not in the vicinity of Piñon Jays. Moynihan (1960) suggests that "many but not all species" that tend to form intraspecific flocks may also form interspecific flocks. Our data show, however, that 14 per cent of the solitary species and 9 per cent of the gregarious species that come in contact with the jay flock do associate with it. Innate social attraction cannot be used to explain interspecific flocking with Piñon Jays.

The ability of associate species to mingle and remain with the Piñon Jay flock is probably enhanced by the lack of intraspecific aggression among Piñon Jays. At any one time, less than 5 per cent of the jay flock was involved in intraspecific hostile behavior. Piñon Jays displayed similar aggressive behavioral patterns both intra- and interspecifically. These entailed crouching slightly, pointing the bill at the aggressee and lunging, or flying up at an approaching intruder with legs extended and calling loudly. A direct thrust with the bill is also used to supplant other birds. These patterns could be easily learned and adjustments readily made. The Red-shafted Flicker and Starling used these same general agonistic behavior patterns to displace Piñon Jays. If the aggressive behaviors are easily learned or already in the behavioral repertoire of the species, actual combat that can result in injury and/or exhaustion is reduced or avoided (Moynihan, 1962). Once an interspecific association is established, the Piñon Jays tolerate the associate species and act with the same low level of aggressiveness towards them as to conspecifics. Therefore the associate species can efficiently reap what benefits are available without expending undue energy. In this regard, the Starling which arrived in northern Arizona in the early 1960's (pers. observ., G. F. Foster) has had only 10 years to learn and adjust to the behavior patterns of the Piñon Jay. Yet in many respects the Starling has the highest degree of behavioral compatibility with the jay flock. This must be due to the behavioral plasticity or preadaptation of this species.

The numerically superior Piñon Jay is also the socially dominant species in mixed flocks, in part because with superior numbers it can displace those associates individual Piñon Jays could not dominate. The associate species rank in an interspecific hierarchy (based partly on compatibility and tenacity when faced with large numbers of jays) as follows: Red-shafted Flicker, Starling, Clark's Nutcracker, Hairy Woodpecker, and Downy Woodpecker. The more abundant associates tend to have higher ranks.

Although the Piñon Jay is largely passive in its behavioral relations with the five associate species, it does possess many of the traits discussed by Moynihan (1960, 1962) which promote both intra- and interspecific gregariousness. The general noisiness and restlessness of the jay flock tend to focus attention on it. The neutral, rather drab blue coloration of the Piñon Jay may act as an attractant to species that are normally repulsed by a sharply contrasting plumage. The dorsal blue or blue-gray coloration is similar to that found in species that form mixed flocks in the Andes and Bolivia (Moynihan, 1968). The associate species show some of these same traits and others, including striking flash patterns on either wings, rump, or tail.

In our opinion the most important characteristics promoting this association are similarities of foraging strategies and similarities in size. Using the

TABLE 5  
INDICES OF SPECIALIZATION ( $J'$ ) OF FORAGING BY PIÑON JAYS AND  
SUM FREQUENCY OF ASSOCIATION

	Jan., Feb., March	April, May, June	July, Aug., Sept.	Oct., Nov., Dec.
$J'$	0.992	0.757	0.716	0.983
Sum* Frequency	3.31	1.81	1.07	3.06

\* From Table 2; Average number of species to be seen with the flock during this period.

suggestions of Pielou (1966) we calculated the foraging diversities ( $H'$ ) and indices of specialization ( $J'$ ) (after Willson, 1970) of the Piñon Jay flock for four different periods of the year (Table 5). The higher the  $J'$  the less specialized and consequently more diverse the foraging pattern.  $J'$  was then compared to the sum frequency (see Table 2; expected number of associate species to be found with the Piñon Jay flock) and a very high positive correlation results. That is, when Piñon Jays are most diverse in their foraging sites, the number of associates is highest.

Numerous workers have pointed out the similarities in body size and weight of members of interspecific flocks. Tables 3 and 4 list weights for the species that occur in the home range of the Piñon Jay at least a portion of the year. The average weights of the associates range from a low of 28 g for the Downy Woodpecker to a high of 142 g for the Clark's Nutcracker. If we eliminate the Downy Woodpecker from this comparison because of its low numbers and obviously low social status, as indicated by the outcomes of interspecific hostile interactions, the weight range for the other four species is 64–142 g. The average weight of 27 adult Piñon Jays is 108 g, almost exactly intermediate to the weight of the associates. This range includes five potential associates, Mourning Dove, Acorn Woodpecker, Steller's Jay, Robin, and Brewer's Blackbird that do not associate. The Steller's Jay is found in high numbers year round, but appears to maintain definite winter home ranges. The other four species are either present in very low numbers throughout the year or are present only during the nesting season when they show strong affinities for nests or territories. Rather than join the flock, these birds all show signs of alarm when the jay flock comes into proximity with them. The typical response was to scold loudly and leave the area. During the warm winter of 1970–71 flocks of Robins occasionally mingled with the jays at watering or feeding sites but did not follow them. Thus, size must be only a secondary factor in determining flocking associates.

Flocking of the five species with Piñon Jays is probably due to their joining the jay flock when food is scattered widely throughout the habitat. The associates are then assured a share of the food. When food is super-abundant, as at the feeding station, attraction to the jay flock is not as evident. This assurance is best demonstrated in those cases of a species associating with the jays when they performed a specific type of foraging. The woodpeckers are most closely associated with the flock during the winter when many jays forage off the ground by flaking bark, probing crevices and opening ponderosa pine cones. The flicker associates most of the year, and there is always a portion of the jay flock feeding on the ground. The nutcracker shows a bond with the jay flock during the time both species are caching piñon pine seeds. Austin and Smith (in press) have shown that some flocking species increase their foraging diversity in winter. This is true in the Piñon Jay. Morse (1970) demonstrated that the associates modify their area of foraging in the presence of socially dominant species whereas Austin and Smith (in press) believe the numerically dominant species may alter their foraging pattern to accommodate the associates. We believe the Piñon Jay increases its foraging diversity during the more demanding winter months in order to obtain an ample supply of food. This, in turn, attracts the associate species. The Piñon Jay is probably more diverse in its foraging patterns than the associate species. This relationship between nuclear and associate species was also shown by Morse (1970) and Austin and Smith (in press).

The tendency of the associates to form mixed flocks is probably a species-specific trait, or set of traits expressed when advantageous, but not necessary for survival except under special conditions imposed by the local ecological situation. Harvesting of vast quantities of food by Piñon Jays may make it advantageous for other species to join them. At the feeding station, only Starlings actively joined the flock. Here food was constantly renewed and the woodpeckers and flickers did not move with the flock when it left the station but stayed to harvest the replenished food items.

Comparing the behavior of the associates at the feeding station to that of the flock in a more natural habitat, suggests that participation in the flock by the associates is directly related to the density and obviousness of the food items. When food is abundant, obvious, and easily obtained the tendency to form mixed flocks decreases. This has also been suggested for insectivorous flocks by Gibbs (1960) and Hinde (1952).

The advantages to be obtained from the association herein described are in all probability food and protection gained by mechanisms similar to those described and reviewed by Morse (1970), for insectivorous flocks. The above author rarely, if ever, observed raptors near or attempting to enter mixed flocks. In contrast, we observed raptors being scolded or mobbed on 42 per

cent of the observation periods, and observed potential predators on 84 per cent of our visits to the home range of the Piñon Jay flock.

When sentries gave the rhythmic danger call, associates responded by flying up into concealing foliage and remaining still. This action was spontaneous and took less than five seconds to complete. The associates never lagged behind the jays in this movement and appeared to recognize the danger call as quickly as did the Piñon Jays. Although Piñon Jays were quick to mob potential predators, only the Red-shafted Flicker and Clark's Nutcracker participated in this behavior. Their participation in scolding and mobbing potential predators was meager as they joined the jays on less than 20 per cent of the scolding and mobbing performances. Thus, the associates gained appreciable protection from the actions of the Piñon Jays.

Associate species and also species that did not associate with the Piñon Jay flock were often, if not always, stimulated by social induction or facilitation (Rand, 1954) to feed when the jays were present. On numerous occasions Steller's Jays and juncos were observed to feed intently with the jays as they passed but these non-associates did not follow the flock when it departed, or only followed a short distance. Westcott (1969) made similar observations on Steller's Jays following a Piñon Jay flock in southern Arizona. Feeding activities of these non-associates ceased when the flock departed. This behavior suggests that all birds may derive some protection from the well organized sentinel system of the Piñon Jay flock. Not only are other species induced to feed in the presence of the jay flock, but they can do so intently because the predator warning system established by the jays allows these species to concentrate solely on feeding. One would suppose that this concentration would increase feeding efficiency. Thus, it is difficult to separate the benefits of associating with the jay flock into protection and feeding efficiency, as both appear to be important but not clearly distinguishable from each other (see Lack, 1968).

#### SUMMARY

The Hairy and Downy Woodpeckers, Red-shafted Flicker, Clark's Nutcracker, and Starling were observed to form interspecific flocks with the highly gregarious Piñon Jay. The general noisiness and restlessness of the jay flock, plus the drab coloration of its members probably acted to attract the associate species. The Piñon Jay flock was intact throughout the year, although in a number of different forms, thus offering attendant species an opportunity to participate in mixed flocking year round. The frequency of occurrence and numbers of associates varied with season and foraging site diversity of the Piñon Jay flock. A strong positive correlation exists between foraging site diversity of the jays and frequency of the associates.

The ability of the associates to remain in the Piñon Jay flock is enhanced by the lack of intraspecific aggression among the jays.

The important characteristics promoting this association are similarities of foraging strategies and secondarily similarities in size.

The benefits derived by associate species as a result of interspecific flocking are probably more effective utilization of the total food resources, indirectly resulting from efficient protection from predators while feeding and directly as a result of the greater ability of numerous individuals to locate scattered, but locally abundant, sources of food.

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#### LITERATURE CITED

- ALLEE, W. C. 1938. The social life of animals. Norton & Co., New York.
- AUSTIN, G. T., AND E. L. SMITH. 1972. Winter foraging ecology of mixed insectivorous bird flocks in oak woodland in southern Arizona. *Condor*, 74:17-24.
- BALDA, R. P., AND G. C. BATEMAN. 1971. Flocking and annual cycle of the Piñon Jay (*Gymnorhinus cyanocephalus*). *Condor*, 73:287-302.
- BALDWIN, S. P., AND S. C. KENDEIGH. 1938. Variations in the weight of birds. *Auk*, 55:415-467.
- BEIDLEMAN, R. B., AND J. H. ENDERSON. 1964. Starling-Piñon Jay associations in southern Colorado. *Condor*, 66:437.
- BROWN, J. L. 1964. The integration of agonistic behavior in the Steller's Jay *Cyanocitta stelleri* (Gmelin). *Univ. California Publ. Zool.*, 60:223-328.
- CARY, M. 1901. Birds of the Black Hills. *Auk*, 18:231-238.
- DARLING, F. F. 1938. Bird flocks and the breeding cycle. Cambridge Univ. Press.
- GIBBS, J. A. 1960. Populations of tits and Goldcrests and their food supply in pine plantations. *Ibis*, 102:163-208.
- HARTMAN, F. A., AND K. A. BROWNELL. 1961. Adrenal and thyroid weights in birds. *Auk*, 78:397-422.
- HINDE, R. A. 1952. The behavior of the Great Tit (*Parus major*) and some other related species. *Behaviour Suppl.*, 2:1-201.
- JENSEN, J. K. 1926. The Piñon Jay (*Cyanocephalus cyanocephalus*). *The Oologists' Record*, 6:41-43.
- JOHNSON, H. C. 1902. The Pinyon Jay. *Condor*, 4:14.
- LACK, D. 1968. Ecological adaptations for breeding in birds. Methuen & Co. Ltd., London.
- MILLER, A. H. 1955. The avifauna of the Sierra del Carmen of Coahuila, Mexico. *Condor*, 57:154-178.
- MILLER, R. C. 1921. The flock behavior of the Coast Bush-tit. *Condor*, 23:121-127.
- MORSE, D. H. 1970. Ecological aspects of some mixed-species foraging flocks of birds. *Ecol. Monogr.*, 40:119-168.
- MOYNIHAN, M. 1960. Some adaptations which help to promote gregariousness. *Proc. XII Internatl. Ornithol. Congr.*: 523-541.
- MOYNIHAN, M. 1962. The organization and probable evolution of some mixed species flocks of neotropical birds. *Smithsonian Misc. Coll.*, 143:1-140.

- MOYNIHAN, M. 1968. Social mimicry; character convergence versus character displacement. *Evolution*, 22:315-331.
- ODUM, E. P. 1942. Annual cycle of the Black-capped Chickadee. *Auk*, 59:499-531.
- PIELOU, E. C. 1966. The measurement of diversity in different types of biological collections. *J. Theoret. Biol.* 13:131-144.
- POOLE, E. L. 1938. Weights and wing areas in North American birds. *Auk*, 55:511-517.
- RAND, A. L. 1954. Social feeding behavior of birds. *Fieldiana Zool.*, 36:1-71.
- SALT, G. W. 1957. An analysis of avifaunas in the Teton Mountains and Jackson Hole, Wyoming. *Condor*, 59:373-393.
- SHORT, L. L., JR. 1961. Interspecific flocking of birds of montane forest in Oaxaca, Mexico. *Wilson Bull.*, 73:341-347.
- STALLCUP, P. L. 1969. Hairy Woodpeckers feeding on pine seeds. *Auk*, 86:134-135.
- TINBERGEN, N. 1953. *Social behavior in animals*. Methuen & Co., London.
- WESTCOTT, P. W. 1969. Relationships among three species of jays wintering in southeastern Arizona. *Condor*, 71:353-359.
- WETMORE, A. 1920. Observations on the habits of birds at Lake Burford, New Mexico. *Auk*, 37:221-247; 393-412.
- WILLIS, E. O. 1966. The role of migrant birds at swarms of army ants. *Living Bird*, 5:187-231.
- WILLSON, M. F. 1970. Foraging behavior of some winter birds of deciduous woods. *Condor*, 72:169-174.
- WING, L. 1941. Size of bird flocks in winter. *Auk*, 58:188-194.

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