SOCIAL ORGANIZATION AND BEHAVIOR OF THE MEXICAN JAY

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The Mexican Jay (*Aphelocoma ultramarina*) as represented in southern Arizona displays a form of social organization which is shared by no other American species of bird north of the tropical regions. By its characteristic occurrence in flocks the year around it is differentiated from typical territorial species; and by the lack of distinct breeding colonies it is separated from the colonial species. Moreover, its relative lack of intraspecific nest defense within flocks is rarely encountered in other species.

Perhaps the aspect of social organization which has aroused the most interest has been the tendency toward a communistic society. Although in territorial and colonial species alike the pair is normally the breeding unit, it has been reported for the Mexican Jay that "even in the breeding season it lives under semicommunal conditions, with mutual interest in all the nests in the community, helping to build and defend its neighbors' nests and young . . ." (Bent, 1946:122).

These unusual aspects of social organization stimulated the present study. Its goals have been, first, to establish in detail the actual social organization in one population through color-banding; and, second, to compare the social behavior of the Mexican Jay with that of a congeneric species possessing a more typical territorial system, the Scrub Jay (*Aphelocoma coerulescens*). It is hoped this will contribute to the knowledge of the processes concerned in the evolutionary bases of behavior and social organization.

METHODS

The area chosen for this investigation was the same one used by Gross (1949) in his study of the Mexican Jay. It lies in Madera Canyon in the Santa Rita Mountains of southern Arizona and spans a range of elevations from 4800 to 5600 feet.

Intensive observations were made on two flocks within the canyon. The territory of the first, or Big Rock flock, included the National Forest Service picnic area called Big Rock Camp (5100 feet). The territory of the second, or Lodge flock, included the Santa Rita Lodge (4900 feet). Both areas were located on the floor of the canyon in the live oak zone and included a stretch of the stream which followed the canyon bed.

The periods of field study were February 1 through 6, and April 23 through May 2, 1958. Captives were studied in Berkeley from February, 1958, through January, 1960. Comparisons with the Scrub and Steller (*Cyanocitta stelleri*) jays refer primarily to the author's studies of populations in the San Francisco Bay and Carmel Valley areas of California.

Jays were readily captured in picnic grounds by using simple, wire-mesh traps baited liberally with conspicuous white bread and sunflower seeds. Each of 50 jays was given a combination of coil-type, plastic, colored, chicken leg-bands which were then cemented shut. No trouble with band loss was experienced.

Jays were aged according to the methods of Pitelka (1945) and, in three cases, with the aid of United States Fish and Wildlife Service bands applied in 1953 by Mr. Donald Bleitz. Sex was determined from brood patch and cloacal protuberance condition for the Lodge flock, but behavioral characters had to be used for the Big Rock flock since its members were not handled during the breeding season. These characters were (1) the laying of an egg, (2) relative time spent on the nest by each member of pair, and (3) industriousness in bringing nest material and working on the nest.

FLOCK STRUCTURE

Flock size.—Two quite distinct concepts are included in the words "flock size." The duality arises from the fact that an entire integrated flock would at times fragment and travel in smaller groups. Thus, a group of jays encountered in the field might not represent the entire flock but only a segment of it. Also, groups from separate flocks under certain conditions, such as mobbing or border contacts, were found in the same place, thus giving the impression of a larger flock than would otherwise have occurred. Therefore, it is necessary to distinguish between the size of groups encountered in the field, which could be counted directly under favorable conditions, and the size of the entire integrated flock, which could be determined only by color-banding combined with prolonged observation.

Observations on sizes of groups counted directly in Madera Canyon in February and elsewhere in Arizona are summarized in table 1. These estimates of the size of groups

TABLE 1

SIZES OF GROUPS OF MEXICAN JAYS ENCOUNTERED IN ARIZONA*

Time	Size	Literature reference or location
Not given	5–20	Stephens (1881) *in* Bailey, 1923
Resident	6–20	Scott, 1886
"Even in breeding season"	15–20+	Swarth, 1904
Feb. 8–10	4–5	Taylor *in* Bailey, 1923
All seasons	6–20	Bent, 1946
Much of the year	6–12	Brandt, 1951
Not given	12–15±	Marshall, 1957
Apr. 1–6, 1958	6	Hardy, 1961
Apr. 1–6, 1958	8±	Hardy, 1961
Apr. 1–6, 1958	12±	Hardy, 1961
Feb. 2, 1958	8+	Kent Canyon, Madera Canyon
Feb. 3, 1958	12±	Bog Springs Rd., Madera Canyon
Feb. 4, 1958	10±	Garbage pit, Madera Canyon
Feb. 5, 1958	15±	Up-canyon, Madera Canyon
Feb. 5, 1958	10–15	Up-canyon, Madera Canyon
Feb. 5, 1958	20–25	Kent Canyon, Madera Canyon
Feb. 5, 1958	10–15	Kent Canyon, Madera Canyon

*Data from literature are generalizations; data from present study are individual observations.

encountered in the field generally agree in placing the usual maximum number of birds at from 8 to 20. The size of flocks can be seen from these records to be remarkably uniform, unlike the autumn flocks which occasionally form in the less gregarious species of *Cyanocitta* and in *Aphelocoma coerulescens*, and unlike the larger, more variable flocks of *Gymnorhinus cyanocephalus*, the Piñon Jay, which exist all year.

In April it was possible to determine more precisely than in February the size of the complete, integrated flock; but the sizes of flocks counted directly in the field remained variable. Such flocks were limited in size by the size of the total flock and were usually incomplete because of the presence of females on nests, the separation of pairs from the flock during nest building, or other activities associated with nesting.

The number of jays composing the entire flock, or social unit, in April was shown by color-banding of individuals to be 13 or 14 for the Lodge flock and 8 for the Big Rock flock (tables 2–5). From the latter flock, however, four individuals were taken in Feb-

TABLE 2

COMPOSITION OF THE LODGE FLOCK OF MEXICAN JAYS IN THE SPRING OF 1958*

Individual	Age	Sex	Bill color	Cloacal protuberance swollen	Brood patch developed	Days observed April 24	25	26	27	28	29	30	May 1	2
MMMXM	5th yr.	♂	BB	+	—	R				+	+	+	+	+
MMRR	A	♀	BB	+	+	R				+		+	+	+
PPPP	A	♀	B	+	+	R				+	+	+	+	+
PPRR	1st yr.	—	WW	—	—	R				+	+	+	+	+
OOMM	1st yr.	—	WW	—	—	R				+	+	+	+	+
YYPP	A	♂	B	+	—		R				+	+	+	+
PPOO	A	♂	BB	+	—		R			+	+	+		+
PMMP	A	♀	WW	+	+		R			+		+	+	+
PRXRP	6th yr.+	♂	BB	+	—		R			+	+	+	+	+
RM–W	1st yr.	—	WW	—	—			R						
W–P	1st yr.	—	WW	—	—				R	+	+	+	+	+
R–M	1st yr.	—	WW	—	—				R		+			
O–P	A	♀	W	+	+					R	+	+	+	+
MYYM	A	♀	BB	+	+							R		+
Unbanded						8							0	

* A=Adult, WW=With much white, W=With moderate white, B=Black except for a few square millimeters, usually at the tip of the upper mandible, BB=Completely black, R=Date of banding.

ruary for behavior studies in captivity, and this may have modified the size estimate made 2½ months later.

Data indicating the size of the social unit in February for the Big Rock flock are presented in table 3. During the period from February 1 through 6, at one banding station within the area occupied by the Big Rock flock, a total of 31 jays were color-banded. However, only under exceptional circumstances were as many as 24 of these seen in the area during the same day. And in these rare cases there was reason to believe that many of these jays belonged to neighboring flocks and only entered Big Rock Camp under unusual conditions, such as the mobbing of owls on February 6. In fact table 3 shows that only 15 were recorded in Big Rock Camp on three or more of the six days of observation. Since all of the 17 jays banded on the first day were subsequently regular visitors, it is probable that the four taken as captives on the same day would also have been regular visitors. The number of unbanded jays in the Big Rock area after the first day of banding was always small, usually one or two at most. Taking 15 as the number of regular visitors and adding the four taken captive and one or two unbanded jays gives a winter flock size of 20 or 21 jays.

Certainly the composition and size of the flock as a social unit must change at times. The difficulties of estimating flock membership from the available information for February compared with the ease of such estimates in April and May suggest that flock size and composition are more variable in winter. These are problems which could easily be studied by workers with opportunities to spend more time in the area.

Age composition.—Table 2 shows that of the 14 members of the Lodge flock in late April and early May, five were in their first year and nine were older. One of the adults was known from previous banding operations (Bleitz) to have been "adult" in June, 1953, and another to have been "immature" at that time. In contrast, of the eight members of the Big Rock flock in April the seven banded jays were all adults, one of which was banded first as an "immature" in June, 1953 (Bleitz). Therefore, a conspicuous difference existed between the two flocks in number of first-year jays.

TABLE 3

COMPOSITION OF THE BIG ROCK CAMP FLOCK OF MEXICAN JAYS IN WINTER AND SPRING OF 1958*

Individual	Age	Sex	Bill color	February						April							May	
				1	2	3	4	5	6	24	25	26	27	28	29	30	1	2
—WR	A	♂	W	R	2	2	7	6	12	+	+	+		+		+		
—GG	A	♂	BB	R		1	2	3	1	+	+	+	+	+	+	+		
WR—	A	♂	BB	R	3		5	4	3	+	+	+	+	+	+	+	+	
RWYY	A	♀	W	R	3	4	4	6	1	+	+	+		+		+		+
—RR	A	♀	WW	R	3	3	2	5	6	+	+	+	+	+		+	+	+
Y—Y	A	♀	BB	R		1	3	4	7		+	+	+	+	+	+	+	
RXWR	5th yr.	♀	BB	R	2	2	1	2	6		+	+		+	+	+	+	+
RYWG	A		W	R	1		3	6	4									
—OO	A		B	R				5	1									
—WW	A		BB	R			2	4	6									
—WG	A		BB	R	3	3	5	8	8									
—WO	A		BB	R			2	4	2									
GW—	A		BB	R			1	3	3									
OO—	A		B		R	1	7	6	8									
WW—	A		B		R													
OR—	A		BB				R		1									
OGO—	A		B				R	3	8									
—ORO	1st yr.		WW					R										
RR—	A		BB					R	1									
WO—	A		W					R										
YGY—	A		BB						R									
YRY—	A		W						R									
—YGY	A		B						R	In neighboring down-canyon flock.								
—YRY	A		W						R	In neighboring down-canyon flock.								
—OGO	A		W						R									
OYO—	1st yr.		W						R									
—OYO	1st yr.		WW						R	In neighboring up-canyon flock.								
R—R	1st yr.		WW	R														
O—O	A		WW	R	captives													
G—G	A		W	R														
W—W	A		B	R														
Unbanded				+	+	+	+	+	+	1	1	1		1		1		

* For February the number of occasions on which the individual was seen during the day in the Big Rock Camp area is entered in the table. For April and May only the presence of individuals was noted. No attempt was made to record every banded jay every day; in fact in May very little time was spent in this study area. Abbreviations as in table 2.

From a total of 24 banded Mexican Jays known to be present in Madera Canyon in April, 1958, six were in their first year and 18 were older, with at least three almost five years old or more (tables 2 and 3). In the entire winter sample of 36 banded jays (not including the spring Lodge flock sample) only four were in their first year. It would seem from these data that differences between flocks in the proportion of first-year birds can be greater than differences in proportions of first-year birds in the population between winter and spring.

Bill color.—In addition to plumage characters, bill color also has a relationship to age in the Mexican Jay, although one that is less clear (Pitelka, 1945). Taking the February and April banding samples together, the bills of all of the nine first-year jays were blotched with white or horn-colored patches. In eight of these the blotching was conspicuous. The three adults known to be almost five and six years or more old had completely black bills. Of the other 38 adults of unknown age the bills were completely black in thirteen, black except for a few square millimeters in 11, moderately blotched with white or horn color in 11, and conspicuously blotched in three. All five adults with

TABLE 4
ACTIVITIES OF ALL MEMBERS OF BIG ROCK CAMP FLOCK OF MEXICAN JAYS IN RESPECT TO NESTS FROM APRIL 25 TO MAY 2, 1958*

	RW–YY ♀ adult	–WR ♂ adult	–RR ♀ adult	Unbanded ♂ –	Y–Y ♀ adult	–GG ♂ adult	RXWR ♀ adult	WR– ♂ adult	Unidentified	Minutes of observation	Number of observations
Minutes on nest exclusive of nest robbing visits											
Nest 1a	190	49	....	½	....	¼	....	....	7¼	430	37
1b	....	....	89¼	4	....	¼	....	....	....	114	15
2	....	....	....	....	21½	8	7	....	44	305	22
Q	....	....	....	....	....	....	1	½	....	76	7
Number of occasions observed bringing nest material											
Nest 1a	....	....	....	....	....	....	....	....	....	430	0
1b	....	....	7	3	....	....	....	....	....	114	10
2	....	....	....	....	....	1	2	....	....	305	3
Q	....	....	....	....	....	....	3	2	....	76	5
Number of occasions observed robbing nest lining											
Nest 1a	....	....	....	....	4	4	3	5	2	430	18
1b	....	....	....	....	....	....	....	....	....	114	0
2	....	....	....	....	....	....	....	....	....	305	0
Q	....	....	2	....	....	....	....	....	....	76	2

* Data are from totaled observation periods of 30 or more consecutive minutes each.

blotched bills in the Lodge and Big Rock flocks had active nests in contrast to the observation of Hardy (1961) and Gross (1949) that only jays with fully black bills were intimately associated with nesting activities. Because their birds with blotched bills were apparently not aged, they could all have been first-year birds.

A jay trapped in February, 1958, as an adult with a moderate amount of white blotching on the bill had not decreased the amount of white blotching in captivity by February, 1960, at the age of at least three and a half years. Similarly the parti-colored bills of two jays kept by Hardy (1961) for almost two years did not change much. However, two adults with black bills, except for the terminal millimeter or so, captured by the author at the same time in Madera Canyon, attained completely black bills in captivity by May of the same year.

Sex and breeding condition.—Only adults present in April could be sexed. On the basis of morphological characters, five adult females and four adult males were identified in the Lodge flock. This imbalance was associated with the presence of two females and only one male at nest 7 (table 5). On the basis of behavioral characters, four males and four females were identified in the Big Rock flock.

All of the four adult males of the Lodge flock handled in April had swollen cloacal protuberances and lacked any signs of a brood patch. All of the five adult females of the Lodge flock handled in April had swollen cloacal protuberances and obvious brood patches in various stages of development. Furthermore, all 18 color-banded adults in the Lodge, Big Rock and other flocks were observed participating either in courtship or nesting activities. All of the 16 banded adults in the Lodge and Big Rock flocks were associated with particular nests.

In contrast, none of the five first-year jays in the Lodge flock showed any enlarge-

ment of the cloacal protuberance or signs of development of a brood patch in late April, at the time when the adults of the same flock were building, laying, and incubating (table 6). Some nesting activity in these first-year jays was, however, observed. PPRR was seen on May 1 trying to pick up a loose twig in its bill; three minutes later it had some fibrous nest material in its bill. W-P on April 28 chased an Acorn Woodpecker (*Balanosphyra formicivora*) from the tree where nest 7 was located. Later W-P was on nest 7 but was pushed off by the female owner at that time (PMMP). On the next day W-P pulled some fibers from a hemp rope and flew with them to nest 7. Gross (1949:244) mentioned seeing a "one-year old" jay with nesting material.

FLOCK DYNAMICS

Stability of flock membership.—The gregariousness of Mexican Jays has been commented on by many authors. But whether the flocks are random aggregations of jays which happen to be in the area or whether they have a relatively stable membership through the course of a day, a week, or longer has not previously been studied.

In April and early May the membership of the Big Rock and Lodge flocks was strikingly constant during the entire period of study. The Big Rock flock was composed

TABLE 5

ACTIVITIES OF ALL MEMBERS OF LODGE FLOCK OF MEXICAN JAYS IN RESPECT TO NESTS FROM APRIL 25 TO MAY 2, 1958*

	PM–MP ♀ adult	O–P ♀ adult	PP–OO ♂ adult	PPPP ♀ adult	MM–MXM ♂ adult	MMRR ♀ adult	PRX–RP ♂ adult	MYYM ♀ adult	YYPP ♂ adult	PPRR 1st-year	OOMM 1st-year	RM–W 1st-year	W–P 1st-year	R–M 1st-year	Unidentified	Minutes of observation	Number of observations
Minutes on nest exclusive of nest robbing visits																	
7**	98½	....	¾	....	....	¼	....	....	....	....	....	....	¼	....	....	174	15
7***	....	159	1¼	....	¼	¾	....	....	....	....	....	....	½	....	....	230	25
8	....	....	....	36½	9¾	....	....	....	....	....	....	....	....	....	12¼	213	33
11	....	....	....	....	....	92	1	....	....	....	....	....	....	....	¼	92	4
9	....	....	....	....	....	....	....	1	....	....	....	....	....	....	1	87	2
10	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0	0
Number of occasions observed bringing nest material																	
7**	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	1
7***	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0
8	....	....	....	9	4	....	....	....	....	....	....	....	....	....	2	....	15
11	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0
9	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0
10	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0
Number of occasions observed robbing nest lining																	
7	....	....	....	8	....	....	....	....	....	....	....	....	....	....	2	....	10
8	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0
11	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0
9	....	....	....	1	....	....	....	....	....	....	....	....	....	....	2	....	3
10	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0

* Data for minutes on nest are from totaled observation periods of 15 or more minutes each. Data for bringing nest material and nest robbing include a few observations additional to these periods.
** April 28–May 1.
***May 2.

of seven adults previously banded in February and one unbanded jay which could be individually identified by its characteristic bill markings. At no time during the entire period of study from April 24 through May 2, were any individuals other than these eight seen associating with the Big Rock flock or seen in the area usually frequented by the flock. Furthermore, none of these eight individuals was ever observed associating with other flocks or in areas frequented by other flocks during that period. Table 3 shows that each individual was recorded in the flock area almost every day, although systematic attempts to see every individual every day were not made. Absence of a record for a day is probably a result of the fact that much of the observation time in April was spent watching individual nests, some of which were not in the Big Rock area but in the Lodge flock or other areas.

The Lodge flock was composed of 14 color-banded jays, all but one of which were banded in April before the period of most intensive study of this flock from April 28 through May 2. As in the Big Rock flock, there was no evidence that any individuals from other flocks associated with the Lodge flock. On a few occasions when jays from the neighboring flock at Madera Camp were seen in the area frequented by the Lodge flock, they quickly left for their own area when the members of the Lodge flock approached. Similarly no members of the Lodge flock were ever observed associating with other flocks or were seen in areas known to be frequented by other flocks. Daily recording of the individuals coming to the banding station for food or nest material showed that every member of the flock but one or two first-year birds were seen there almost every day (table 2).

Attempts were also made to follow the flocks' activities for a period of time while observing their composition. For example, on April 28, 1958, the entire Big Rock flock (eight members) was seen at 5:57 a.m. foraging on seed scattered in the campground. For half an hour the whole flock remained together while foraging and flying individ-

TABLE 6

SUMMARY OF INFORMATION ON STAGE OF NESTING CYCLE AT ACTIVE NESTS IN FLOCKS AT THREE ALTITUDES IN MADERA CANYON*

Nest	Date	Stage
Big Rock Camp flock, elevation 5120 feet		
Nest 1a	April 30	1st egg
1b	May 2	Nest complete; no eggs
2	May 1	1st egg
Q	May 1	Building lining; no eggs
Lodge flock, elevation 4960 feet		
Nest 11	April 30	5 eggs
7	April 30	1st egg
9	April 30	1 egg
8	May 2	No eggs; building lining
10	May 1	No eggs; much lining
Lower Canyon flock, elevation 4700 feet		
Nest 3	May 1	4 warm eggs, 1 with fully formed embryo
4	May 1	4 warm eggs
5	May 1	3 cool eggs

* In Big Rock Camp flock all nests and individual jays were accounted for. In Lodge flock all were probably accounted for. But in the Lower Canyon flock probably not all nests were found.

ually back and forth between a foraging area and a leaf-covered hillside where the seeds were stored in the ground.

More typically a part of the flock would be absent, presumably concerned with nesting activities. For example, on April 30, at 6:20 a.m. six of the flock members were seen again in the same area—some foraging for food and one pair gathering nest material. The absent birds were mated to each other.

The general pattern for Mexican Jay flocks at nesting time seems from this evidence to be one of stable flock composition. Although attachment to their own nests cannot be an explanation of why certain jays only associate with certain individuals, exclusive of the mate, this stability appears to be correlated with nesting. The least regularly occurring individuals were nonbreeding, first-year birds, which showed little if any attachment to particular nests.

During the February study period at Big Rock Camp, the situation was similar in that flocks seemed to have at least a definite core membership, but exceptions to the general rule of constant flock composition were more numerous. When the banded flock was followed as it traveled and foraged through the canyon, the composition was observed to remain the same on several occasions. However, fractions of the flock often remained apart for reasons such as a good supply of sunflower seeds at the banding station. Unfortunately, observation was not continued long enough in February to establish the exact composition of Big Rock and neighboring flocks and their fluctuations.

The information on occurrence of banded individuals in the Big Rock area is summarized in table 3. On the first day of trapping, 13 jays were banded and released. All of these were seen regularly at the banding station on subsequent days. After the first day never more than three unbanded jays were observed in the area at once except during the mobbing of stuffed owls. However, seven more jays were banded before the mobbing incident and seven more after it. The evidence suggests that there was a basic core membership most individuals of which were banded the first day, and that other individuals came to the feeding station from time to time. Whether these other individuals were regular members of other flocks in February is unknown. But none of them was ever seen in any other area except for three jays banded just after the mobbing incident; these were found in April, 1958, in two neighboring flocks. Thus, the extent to which flocks remain as units or intermingle in winter requires further study.

Compositions of the Big Rock flock compared in February and April, 1958, indicate a considerable loss during this period (table 3). Although there were 15 banded individuals recorded on three or more days in the area in February, there were only seven banded jays present in April.

Many factors of flock composition and stability are poorly known. The role of dominance in the organization of the flock is unknown. The existence of a dominance hierarchy within the flock could not be discerned, but the prevalence of intraspecific nest robbing at certain nests and not others suggested its existence. Whether replacements in the flock come primarily from the young raised within the flock or from outside is not known, although of two jays banded as immatures in the Lodge flock by Bleitz one was recovered in the Lodge flock and one in the Big Rock flock four and one-half years later. So far there is no evidence of the existence of a leader. Factors responsible for flock stability, such as inter-flock dominance relations, leadership, or family ties, require further investigation.

Overlap and non-overlap of flocks.—In general, the members of each complete flock restricted their activities to a particular area which was mutually exclusive from the areas occupied by the neighboring flocks.

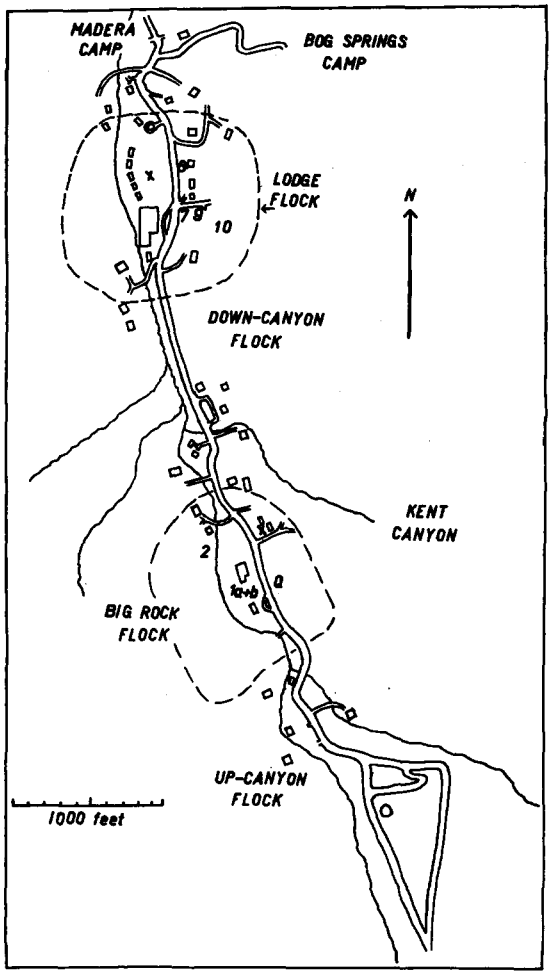

Fig. 1. Map of the study area in Madera Canyon showing location of two color-banded flocks of Mexican Jays (*Aphelocoma ultramarina*) in relation to other flocks, location of active nests in each banded flock (1a, 1b, 2, Q; 7, 8, 9, 10), and location of trapping and banding sites (x).

On February 1 and 2, 1958, fifteen Mexican Jays were color-banded and released at Big Rock Camp (fig. 1). Each of these individuals was seen many times daily or almost daily in the same area for the remainder of our stay. They were seen only in the range occupied by the Big Rock flock and not in the area of other flocks. On February 3, one long and three short periods were spent observing the neighboring down-canyon flock. None of the ten jays seen well enough to ascertain the presence of bands was color-banded. Simultaneously, about 200 yards away, G. H. Orians observed that all the jays but one at Big Rock Camp were color-banded.

Also on February 3, in a flock 1000 yards away (Bog Springs Road), eight unbanded jays were seen and later in the day five unbanded jays, probably also from this flock, were trapped at Madera Camp.

On February 5, in the up-canyon flock, which was also contiguous with the Big Rock flock, five jays on one occasion and ten on another were seen to be unbanded, and no banded ones were seen in the flock. The same day in a third adjacent flock about 360 yards from the Big Rock flock area eight members of the Kent Canyon flock were seen to be unbanded and no banded jays were detected in it (size of flock 20 to 25).

In addition to looking for banded jays out of the Big Rock area, the Big Rock flock was followed as it foraged over its range. In this way an approximate idea of its foraging area was acquired (fig. 1). During these travels the composition of the flock remained roughly the same; the same jays remained together and were not joined by unbanded jays arriving from elsewhere.

Thus, it can be said that in the February period of observation, the 17 jays banded and released at the Big Rock Camp area were seen consistently and only in the area occupied by the Big Rock flock and not in the areas occupied by three of the flocks occupying contiguous areas.

That flocks do on occasion enter areas outside of their regular foraging areas is attested by the following evidence. On February 6, a stuffed Screech Owl (*Otus asio*) on a pole and a stuffed Great Horned Owl (*Bubo virginianus*) hanging on a string and turning in the breeze were hung out in the Big Rock Camp at 11:30 a.m. At 2:40 p.m. the Big Rock flock discovered the owl mounts and mobbed them intensely for over ten minutes. Seven of the ten jays seen closely enough to be identified were banded and belonged to the regular Big Rock flock; three were unbanded and could also have belonged to it. Then, after most of the mobbing activity had waned, a new flock which seemed almost entirely unbanded discovered the owl mounts at 3:45 p.m. Seven of the birds were seen to be unbanded; also one banded jay was recovered which had been banded two days previously but which had not been seen since. After the mobbing by this second flock had subsided, seven new jays were trapped and banded when they fed in the baited area. This was in contrast to the previous four days when it had only been possible to band a total of seven new jays for the whole period. It was improbable that as many as seven unbanded jays traveling as a unit unaccompanied by any of the regular visitors to Big Rock Camp could actually have been members of the Big Rock flock. These newcomers arrived from the direction of the Kent Canyon flock area and eventually drifted back toward the same area from which they had come.

In April one of the jays banded after the mobbing incident in February was discovered in the next flock up-canyon from the Big Rock flock, and two jays banded earlier the same day in February were found in the next flock down-canyon. Thus, in February they were probably visitors from neighboring areas and not regular members of the Big Rock flock.

No aggressive interactions between members of the Big Rock flock and the presumed Kent Canyon flock were observed on the occasion of the mobbing. But on the first day of artificial feeding of jays before banding operations began, several actual fights between individuals were seen. Fights were never seen again after the first day.

Also, single unbanded individuals appeared in February from time to time at the feeding station. It seemed quite possible that the abundance of food offered in the baited area was a factor in attracting jays from outside the regular flock to spend more time there than they would have otherwise.

Hardy (1961:49) wrote, "In nonbreeding activity, two flocks previously distinct while breeding typically unite . . . ." Since his observations were made on unbanded jays and details were not given in support, the bases for his conclusions are not clear.

The area occupied by the Big Rock flock in April was found by following the flock

to be virtually identical with that occupied in February. A change of 10 per cent or so could, however, have occurred unnoticed.

As in February, there was in April and May no evidence that the Lodge or Big Rock flocks ever traveled outside of their regular area or that other flocks entered their areas. This mutual exclusiveness in regard to flock composition and the areas occupied by the flocks indicates that a form of flock territoriality exists. Accordingly opportunities were sought to observe encounters between flocks at their mutual borders; but these were apparently very rare, for none was observed even though efforts were made to bait two neighboring flocks to feed together at a common border and to chase one flock into the area of another.

Only a few observations in regard to inter-flock contacts are available, but they are in agreement with the concept that territory of a flock is maintained by aggressive interactions at the territory borders. First, it has already been mentioned that visitors from outside the territory of the Big Rock flock probably occurred not uncommonly in February but were never observed in April. This can be partly explained by the lack of baiting in April, but it is consistent also with the development of territorial behavior in the spring as is the fact that the area occupied by the Big Rock flock had not changed.

Second, an encounter between members of two flocks was observed on May 2, at 7:40 a.m. An unbanded jay from the area of the flock neighboring the Lodge flock on the down-canyon side crossed the border and flew well into the area of the Lodge flock near nest 8. After a minute, it was seen flying silently and swiftly back toward its own area pursued by five members of the Lodge flock, all calling loudly. The male of nest 8, the female of nest 7, and two first-year birds were identified among the five members of the Lodge flock. While I was running to the scene much more calling was heard, which suggested that the members of the Lodge flock had met more members of the neighboring flock there at the border. When I arrived the birds returned to their own areas. Similar chases, in which the individuals could not be identified, were seen from a distance twice near the up-canyon border of the Big Rock flock area.

In the course of banding operations at the Santa Rita Lodge, occasionally a single banded jay was seen attracted to the food in back of the cabin. This jay appeared nervous and would fly into the area of the neighboring flock upon hearing the calls of the members of the Lodge flock on the other side of the house.

These observations taken together point to the existence of flock territoriality in the Mexican Jay. However, they are too few in number, and more observations of contacts between members of color-banded flocks and individuals will be necessary for a definitive statement. Defense of the territory against outsiders also poses the problem of how individual jays first join a flock and the seasons when this is most common.

Responsibility for nests.—There was no subdivision of the areas occupied by the Lodge and Big Rock flocks into separate sections where pairs were found to the exclusion of other flock members. This was determined for the Big Rock flock in February by following the flock as a unit and in April by plotting the places where individuals were seen on a map of the area occupied by the flock in addition to following the flock as a unit. General observation of the Lodge flock revealed the same situation. Although the owners of nests were seen more frequently in the vicinity of their own nests than were other flock members, at no time was any behavior seen which suggested defense of a nest area by any individual or pair.

Nests built farther away from the areas most often frequented by the flock were not so often visited by the flock, and such nests (for example, 2, 10) seemed to be less exposed to the dangers of interference than ones located more centrally in the flock area

(for example, 1a, 7), although this was probably not the only factor leading to interference. Location of nests within the flock area followed no consistent pattern. Some were as close as six feet (1a, 1b) or 15 feet apart (4, 5), but in other cases nests were almost at opposite ends of the flock area (Q, 2; 10, 8).

The common observation of a flock of Mexican Jays alighting in a nest tree during nest construction or as the brooding female or young were fed has led to uncertainty as to which and how many flock members assumed the responsibilites for each nest, for in no previous study was color-banding employed. Miller (1932) noticed a "pair" feeding a juvenile. Bent (1946:122) mentioned that flock members were mutually interested "in all the nests of the community" and that they helped in building and defending their neighbors' nests. Gross (1949:242) wrote, "This nest was being built not by a single pair of birds, but at times by as many as seven or eight. This [is a] well-known communal habit...." However, he added, "Usually only one, rarely two, but at one time three of the jays were carrying sticks as they arrived. The other members of the band alighted in the branches of the nest tree and exhibited a great deal of interest in the entire procedure." Two other instances were given of the arrival of the members of a flock at the nest tree while only one individual actually brought nest material. After ten days of incubation only two jays were seen at this nest. Similarly, "after the eggs hatched, only two adult birds were seen about the nest. Bands of jays were seen roving about the neighborhood but as far as I could determine no individuals other than the parents fed the young. There were four nests within close range . . . but each pair seemed independent of the others" (p. 247).

Brandt (1951:392) mentioned that, "frequently more than one jay accompanied the bird that was carrying and handling the nest material," and he also wrote: "On more than one occasion I have seen three birds feeding young at a single nest."

In *Aphelocoma ultramarina couchii* of Texas, behaviorally quite different from the Arizona subspecies, Brandt (1940) and Van Tyne and Sutton (1937) noticed only pairs at nests.

In the present study visits by the flock or fractions of it to the nest trees and their immediate vicinity were common, but the given pair which actually landed and worked on the nest itself was in the great majority of cases the pair of birds definitely responsible for its own nest and no other. The other jays of the flock only occasionally landed on nests not their own except in nest robbing (see beyond). Thus, some of the appearance of participation of the whole flock in the affairs of each nest can be explained in this way.

In the Big Rock flock the ownership of each of the four nests could be easily assigned to a particular pair of jays. This was evident in the confident manner in which the owners approached their nests, in contrast to the hesitant approaches of some non-owners. Further evidence for the existence of pairs was the association of known males and females together in hunting for nest material and in other activities.

From time spent on the nest and bringing of nest material, quantitative indices of ownership could be obtained. The time spent on each nest by each individual in the Big Rock and Lodge flocks during almost 29 hours of observation at nine nests is shown in tables 4 and 5. Time spent in nest-robbing visits is not included in the totals.

In the Big Rock flock, female RWYY and male –WR spent 190 and 49 minutes on nest 1a but were never observed on any of the other three nests; and other identified members of the flock visited nest 1a for a total of not more than three-quarters of a minute in 430 minutes of observation. For nest 1b ownership was similarly clear: Female –RR landed only on her own nest (1b). Nests 1a and 1b were only six feet apart

and at the same height; although the unbanded (but individually recognizable) male usually went to 1b, on two occasions he landed first on 1a with nest material, looked around as if realizing his mistake, then directly deposited the material at 1b.

The principal exception in the Big Rock flock to the generality that pairs were strictly concerned with their own nests was female RXWR. Her nest was not found until near the end of the study, so only few observations were made there. She was, however, the only female seen on the nest, and she brought nest material three times. The male WR– similarly was the only male seen there, and he brought nest material twice. Female RXWR also visited nest 2 four times for a total of seven minutes and twice brought nest material there. However, she spent only a third as much time there as the female owner, Y–Y, and was once pushed off the nest by Y–Y.

In the Lodge flock, although pairs and nest ownership could be determined, irregularities were present, in part due to the excess of females (table 5). Nest 7 was attended from April 28 through May 1, primarily by female PMMP and male PPOO. It also received one visit by a first-year bird and another by an adult female. On May 2, female PMMP was not seen at nest 7 again and in her place was female O–P. How this switch occurred was not observed. PMMP was still with the flock. O–P had been seen once previously at nest 10, the only jay ever to be seen there. Among the various possible explanations are desertion of nest 10 by O–P in the absence of a mate, bigamy on the part of male PPOO, and desertion by female PMMP. Since nest 7 was frequently robbed of lining and PMMP was frequently pecked and attacked while sitting on it, the possibility of desertion seems not unlikely. O–P was notably more effective in defending nest 7 than was PMMP. On May 2, there were also one visit by a first-year jay and three brief visits by female MMRR, who apparently had deserted nest 11 after its egg and lining had been robbed by Mexican Jays on April 30.

Nest 8 was owned by female PPPP and male MMMXM exclusively, so far as could be observed. These individuals were not observed visiting any other nests except to rob them. This was the only nest in the Lodge flock area still being actively built and only these two jays brought nest material to it.

At nest 11 female MMRR was incubating the whole period of observation and was visited once and probably twice by male PRXRP.

Nest 9 had a short history. At the time of its discovery it was visited by female MYYM. Forty-five minutes later the one egg was robbed. After that no further activity except robbing of nest lining by the owners of nest 8 was seen there.

At nest 10, O–P was seen once leaving, but no other jays were ever seen there. It seemed to be a fresh nest.

Although many questions about the individual nests and birds remain unanswered for the Big Rock and Lodge flocks, the general pattern may be seen. The adult birds were associated in pairs, each pair with its own nest. The flock visited the nest trees, but visits to the nests themselves by jays other than the owners were exceptions. Whether the members of these pairs remained together in subsequent years as in the Steller and Scrub jays is unknown.

No threesomes were found. At nest 7 where two females were active, a change in ownership seemed to have occurred, for the two females were never there together or even on the same day. Only one of the nine banded females, RXWR, showed much interest in nests other than her own, and she was once rejected by the female owner rather than incorporated into a threesome. The occasional visits of first-year and other jays might also have contributed to the appearance of threesomes, but in this study such visits were unusual.

Despite the responsibility of specific pairs for their own nests, there were more nest visits (other than for nest robbing) by non-owners than would be expected in a typically territorial species. In a total of 28.7 hours of observation on eight nests in the Big Rock and Lodge flocks, 23 visits by non-owners were recorded as opposed to 116 visits by owners in the same period. As shown in tables 4 and 5, the total time spent on nests by non-owners was small in comparison to that by owners (one per cent of the total time that all individually identifiable jays were seen on nests). Three of the four nests in the Big Rock flock and one of the four Lodge flock nests were visited by non-owners during the period of observation. The non-owners brought nest material, fed the brooding jay on the nest, actively worked on the nest, or briefly inspected it.

In short, the Mexican Jay in Madera Canyon exhibited an unusual extent of communal participation in nesting activities, but primary responsibility for each nest lay with the pair rather than the flock as a whole. The factual evidence from the literature cited at the beginning of this section is in basic agreement with this finding, although the impressions of some authors have tended to exaggerate the phenomenon of communal responsibility.

Participation of sexes.—In construction and time on the nest, the female played a more active role than the male. Of 31 occasions when nesting material was brought by a jay of known sex, it was brought by a female 21 times. And in each of the three pairs observed engaged in nest building, the female brought material more often than the male (tables 4, 5), except at nest 2, where the male once brought material and the female not at all. Females were observed to work industriously on their nests, but males worked on nests only occasionally. Of 15 occasions when the sex of the jay working on the nest was noted, females were observed 13 times (three nests). In time spent on the nest the major role of the female is shown in tables 4 and 5. Only females were observed incubating eggs.

Intraspecific nest robbing.—A conspicuous feature of the Big Rock and Lodge flocks not commented on in earlier accounts of the Mexican Jay was the high frequency of visits by non-owners for the purpose of robbing nest lining material and in one case an egg (witnessed by Esther Brown) from the nests of their own flock members. Gross (1949:244) saw jays taking "hair from the interiors of deserted jays' nests," which became the major source of lining for the nest he watched. During the observation periods summarized in tables 4 and 5, 33 visits in which nest lining material was robbed from active nests of flock members were recorded as opposed to only 23 visits of a neutral or constructive nature by non-owners. Two of the four active nests watched in each flock were seen being robbed; while three of the four nests in the Big Rock flock and one nest in the Lodge flock were visited by non-owners in activities other than nest robbing.

In the Lodge flock, only female MMMXM was observed nest robbing and mostly at nest 7. All other nests belonging to members of the Lodge flock, except that belonging to MMMXM, had already passed the stage of lining construction (table 6) and, therefore, the stage in which their owners might also have participated in robbing of nest lining material.

In the Big Rock flock, five of the eight individuals were observed robbing nest lining from the nests of other flock members. The nests of all the robbing jays were still under construction. The pair which was in the most advanced stage of the breeding cycle judged by the laying of the first egg was not observed robbing, and its nest was the most frequently observed being robbed. Thus, in both flocks the pairs behind in the breeding cycle plundered the nests of pairs which were ahead.

The effect of repeated robbing on the structure of a nest was drastic in the case of nest 1a. Although some lining was present and also even some building activity on April 25, there was no lining at all by the end of the next day. Despite this an egg was laid on the platform of twigs on April 30, and another on May 2. These could be easily seen through the bottom of the nest from beneath. At nest 7 the lining was noticeably sparser after three days of being robbed than before.

The bills of three of the four female owners of victimized nests were blotched with white. The bills of five of the six robbing jays were completely black. A correlation with age and perhaps, therefore, with dominance position in the flock is suggested by these data, although other evidence of intra-flock dominance relationships was conspicuously rare.

The robbing of nest lining was attempted whether the owners were present at their nests or not. When the owners were absent, the raider usually took a bill full of lining fibers and flew directly to its own nest. On one occasion when another non-owner was on the nest, the raider pushed it off and then took some lining. When the owners were present, the behavior varied. When both owners were sitting on the nest at once, thus largely covering the nest, one raider was still able to reach under the owners and pull out nest lining material; more often it pulled out bits of lining from the side or the bottom of the nest or picked up loose pieces of lining material which had fallen from the nest into the branches below. In contrast to the usual situation in the nest robbing of other species, the raider was usually more vigorous in its aggressiveness than the nest owner was in defense. When the owner resisted by begging, the raider on at least four occasions pecked it viciously on the crown or in its gape.

Defense by the owners against these nest-robbing activities was surprisingly slight and consisted principally of sitting on the nest. As the sounds of the flock approached a nest, the owners would sometimes appear and just sit on the nest until the flock had passed. Scott (1886) noticed the unusual amount of time spent by Mexican Jays on their nests before incubation began but attributed it to the danger of confusion in the ownership of nests. Not uncommonly both members of the pair would sit side by side. This was most conspicuous at nest 1a, the most heavily victimized nest, where the male in five visits sat with the female for 35 of the 190 minutes she was on the nest in 430 minutes of observation.

On at least ten occasions one of the sitting owners begged at the robbing jay. In begging the owner would sit deeply in the nest, quiver the wings, gape, and give a vocalization rendered phonetically as *aaah* repeatedly.

On only two occasions was fighting in defense of a nest against a nest robber observed. In the first the female owner and an intruder were pecking at each other while both were sitting on the nest when a third jay, probably the male owner, arrived and chased the intruder away. In the second case the raider landed on nest 7 with the female owner (O–P), who was sitting in the nest, pecked the female a few times, then stood a foot away as the male (PPOO) arrived, fed the female, and left. Then the raider jumped to the edge of the nest and jabbed the female on the crown and in the gape. The female then jumped above the raider and pecked it viciously. After fighting for a few seconds the raider left and the female owner returned to her nest. At this nest (7), the previous female owner was never seen to resist any nest-robbing attempts by fighting, but only by begging.

The role of the sexes in robbing was different in each flock. In the Lodge flock only one pair was seen robbing nests, and only the female (PPPP) actually took material from the nest. The male (MMMXM) almost always accompanied her and sometimes

picked up material which had fallen, but he was never actually seen to rob a nest. In the two pairs seen nest robbing in the Big Rock flock the male and female robbed about equally as often.

Robbing of nest lining material from jays' nests was not confined to jays alone, for on one occasion a female Black-headed Grosbeak (*Pheucticus melanocephalus*) was also seen robbing an active nest (Q).

Flock differences in stage of nesting cycle.—Within Madera Canyon nests were discovered belonging to members of three flocks, each separated from the other by intervening flocks and each occupying a different range of elevations. The area occupied by the Big Rock flock was at about 5120 feet, the Lodge flock was at about 4960 feet, and the Lower Canyon flock was at about 4700 feet. The average stage of the nesting cycle of each flock was correlated with its elevation on the canyon floor (table 6). The Lower Canyon flock was most advanced, with all three nests discovered holding three or more eggs; the Big Rock flock was the least advanced, with no nests containing more than one egg. The photoperiod in the narrower, upper part of the canyon was probably shorter than that in the lower part of the canyon.

BEHAVIOR

Nest-building movements.—Females which were watched while constructing their nests during the lining phase characteristically sat in the nest cup and worked on it by grasping loose wisps, straws, and fibers in their bills and with vibrating movements of head and bill thrust them into the nest lining, or, if twigs, into the nest platform. A typical movement in the latter case was to grasp a twig crosswise and with vibrating head and bill to rotate it 10 to 20 degrees with considerable force, thus working one end of the twig into the nest more securely. Another set of actions sometimes seen consisted of fitting the breast down snugly in the nest with a little fluttering and refolding of the wings over the back and raising of the tarsi behind. From the rear the tarsi could be seen making alternating pushing movements similar to ones described by Beer (1961) for the Black-headed Gull (*Larus ridibundus*) from under his glass-bottomed nest.

Foraging and storage.—In February the flocks were rarely observed foraging anywhere except on the ground in leaf litter, although the flocks often progressed through the trees. In April foraging on the ground was frequent, but food was also sought among the newly opened oak leaves and along trunks and branches.

Flock members typically foraged within a relatively short distance of each other. When food items were found, it was frequent in the picnic areas to see four or five jays together on the ground about two or three inches apart, sometimes even closer. Such mutual proximity among individuals was in striking contrast to Steller and Scrub jays, in which distances between unpaired individuals of less than ten inches were rarely observed without aggression.

The nature of the food found in winter was not determined. However, despite an abundance of oak trees in Madera Canyon, jays were not seen with acorns either in February or April. Among Steller and Scrub jays in Berkeley, California, acorns were almost never seen after the autumn crop was gone from the trees. Apparently stored acorns and other nuts were not an important food item in these jay populations after autumn.

Several actions concerned with the handling of food which are typical of jays and certain other taxonomic groups were recorded. One was the beating of a caterpillar over a branch (seen also in Scrub Jay) before bringing it to the mate on the nest. A second was the manner of digging in soil or leaf litter with sideways jerks of the bill first in one

direction and then in the other, spraying aside dirt with each jerk (seen also in Scrub and Steller jays). Another was the treatment of hairy caterpillars. A captive Mexican Jay took one in its bill and rubbed it on the ground through wood shavings in an arc five to six inches long, releasing it occasionally and then rubbing it some more. The same treatment was seen given to a lump of rough mash on two occasions. Such behavior has also been observed in both wild and hand-reared Scrub Jays. A fourth, which is probably universal in the Corvidae, was the holding of food items with the feet on the perch while pieces were pulled off and eaten with the bill.

The manner of storing food in the ground consisted of the following acts in Mexican, Scrub, Steller, and Blue jays: (1) selection of a suitable place for storage, usually while jumping unhurriedly along on the ground and testing various places by inserting the bill and then withdrawing it again, (2) insertion of the object in the bill into the soil roughly the full length of the bill, (3) withdrawal of the bill, sometimes, perhaps always, preceded by expulsion of the stored item from the bill by the tongue, (4) tamping—the bill is reinserted and the tip used to push the object farther and more securely into the soil, (5) covering of the hole first by sideswipes of the bill, which are the reverse of digging movements, and then by the picking up of a suitable cover, such as a leaf, piece of bark, or paper (if available) and placing it over the spot. The act of storage by Mexican Jays was observed several times in Madera Canyon, and it was often observed in captivity. The entire sequence was generally completed unless interrupted by sudden alarms. Gross (1949) mentioned the covering of food with fallen leaves and the storage of food in crotches and cavities of trees.

Rattle.—Probably the most interesting aspect of the vocabulary of the Mexican Jay in Arizona is the rarity or absence of a call comparable to the "rattle" of Scrub, Steller, and Blue jays. The rattle in these species consists of a mechanical sound similar to that made by running a fingernail over the teeth of a comb. Such a call was never heard from any Mexican Jay at any time either in the jays of Madera Canyon or in captives of both sexes brought back to Berkeley. Furthermore, there seems to be no description of it in the literature. This call has been noted in the population of Mexican Jays in Texas, however (Van Tyne, 1929), and the difference between the Arizona and Texas populations in this respect was pointed out by Brandt (1940).

Song.—The word "song" is used, not because the vocalization compares functionally with the songs of other passerine species, but because it compares in length with the songs of other species and has been referred to in earlier literature as song. Although song was not heard from jays in Madera Canyon, it was commonly heard from the captives studied in Berkeley, California.

In its form, length, and loudness, and in the postures from which it was given, the song of the Mexican Jay was similar to those of the Steller and Scrub jays. For a jay, it was a relatively long, protracted, continuous vocalization with no obvious beginning or end. Three songs which were timed were 15, 22, and 32 seconds long. Songs varied in loudness but were always subdued and usually barely audible at distances of ten feet or more. They consisted of garbled, run-together series of *weet* notes and others similar to normal calls in quality and pitch, but subdued in volume, and with various inflections. The songs of Mexican, Scrub, and Steller jays all were composed basically of the calls characteristic of the species with variations and could thus be differentiated.

The song was given from a characteristic posture (fig. 2) with the throat visibly moving, the bill near horizontal, virtually closed, and the mandibles barely moving. During the entire song, the head was held somewhat forward and was turned slowly and regularly through an arc of about 180° from side to side. In some cases lateral fluffing of the breast feathers was noted.

Song was recorded in captive birds most frequently in May, but it was also heard in March, June, and August. All the jays which sang were adults. No first-year jays were kept. The individual which sang most frequently was a female, but song was also heard from each of two males. Identification of sex was by dissection for one male and the single female and by behavior and lack of a brood patch for the second male.

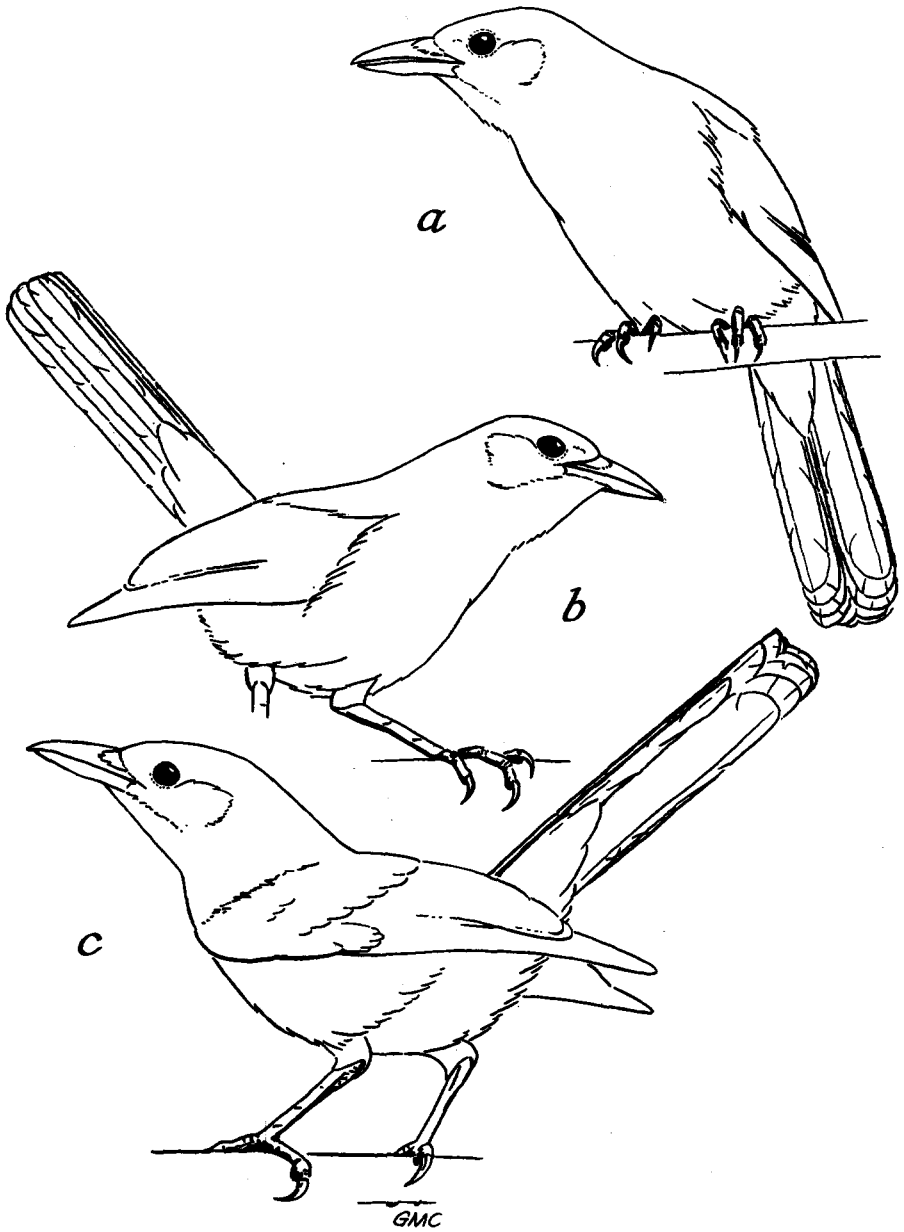

Fig. 2. Characteristic postures of the Mexican Jay. a, Singing posture; b, c, "rocking" postures during mobbing with *weet* calls.

Song was given in various contexts. It was given twice when my presence caused some hesitation in jays going to freshly put out food and twice when I was about to enter the greenhouse where the jays were kept. In May during the period when male O was driving males W and Y away from female R and also courting and feeding her, R several times sang at W and Y, even when they were separated by a wire screen.

Guttural.—The calls here covered under the term "guttural" include a variety of low-pitched, low-amplitude, single-syllable sounds something like *cuck, cluck, uh, quick, up,* and so on. Such notes were continually heard from unalarmed flocks at close range; they could not be heard from a moderate distance. A continual, conversational chatter of guttural notes at times seemed to function in keeping the flock together. Only in alarm or in other special circumstances were other calls employed. Gutturals were similar in sound to notes used between members of mated pairs of Steller and Scrub jays at the nest, during nest building, and during a great variety of other relatively quiet activities. Probably they serve a similar function in all three species, namely maintaining contact and mutual interest in the activity of the flock or pair without attracting too much attention. Gutturals were not typically accompanied by characteristic postures or actions.

Weet.—The call designated *weet* in this paper was the only loud, clear call of the Mexican Jay heard in Madera Canyon and the one by which the species is probably best known. It probably corresponds to the *wait* of Brandt (1951), the *wack* of Bent (1946), and *weent! weenk! weenk!* of Taylor (*in* Bent, 1946). This call was generally louder than any of the other calls of the Mexican Jay but varied in loudness with the circumstances. It was relatively high-pitched for a call of a jay, although the pitch also varied. It was given singly or rapidly repeated. Often it seemed to be given in particular phrases with a few to many notes in a phrase, the phrases differing in pitch and inflection.

Although these vocalizations could probably have been subdivided and given separate names on the basis of pitch, loudness, phrasing, inflection, and so forth, such breakdowns could not be consistently justified because of my relatively brief study period. In general the jays gave single, weak *weets* when only mildly alarmed and loud, varied, long phrases when greatly alarmed. Thus, the degree of danger-oriented arousal seemed to be the most consistently correlated motivation variable associated with these vocal variations.

The contexts in which *weets* were given were not analyzed quantitatively, but mention of some of them may be made. In general, the impression gained in watching a flock working through its foraging area was that guttural notes were the normal means of vocal communication unless something unusual and alarming was discovered at which times *weets* would be heard. *Weets* were given at a wild bobcat (*Lynx rufus*), at stuffed owls, at humans inspecting nests, and in captivity at a live Great Horned Owl, a live gopher snake (*Pituophis catenifer*), and at any humans who came near the aviary. *Weets* were the calls used in mobbing of all sorts.

On one occasion *weets* were used by the members of one flock while pursuing a member of another flock back to its own area.

In some contexts the call was employed in situations characterized by escaping. In three cases when sitting jays were scared from their nests either by a thrown stone or by the approach of a human, the jays fled directly away calling *weet* and did not return or mob. At least 11 jays gave *weets* when released after banding. This was observed more than twice as often in April as in February although more than twice as many jays were banded in February as in April. Jays occasionally also gave *weets* when held in the bander's hand.

In some cases *weets* were employed more or less clearly as a sort of threat between nest owners and non-owners. For example, the male and female of nest 8 called loudly and repeatedly when a third jay was in their nest tree but ceased when it left. At nest 1a many *weets* were heard from three flying jays; two arrived first at the nest and sat snugly on it while a third landed on the edge and began pulling out nest lining. When the intruder left, the female owner arose and perched quietly on the edge of the nest. At other times jays on their nests gave *weets* in response to *weets* heard elsewhere or when other jays were approaching the nest.

In other cases no opponent could be discerned. Three times both members of a pair were observed giving *weets* as they arrived at or left their nest together. Twice females were heard giving *weets* as they brought nest material to their own nests. And once a female was seen giving *weets* as she settled into brooding position on her nest.

In a few cases *weets* were noted as the members of a pair met at their nest. In one case the female on the nest called *weet* repeatedly as the mate brought nest material. Another nest (11) was located by the exchange of *weets* when a male visited a female on the nest. *Weets* used in greeting sounded less loud and were fewer and less rapidly uttered than those given in threat or mobbing.

The postures and actions accompanying the utterance of *weets* varied with the loudness, rapidity, and number of calls in a phrase. They varied in intensity, the highest intensity occurring typically during mobbing. The simplest specialized accompanying action was a simple upward jerking of the tail with each vigorous call. A slight flick of the wings simultaneous with the tail jerk was sometimes added. In the extreme development of these actions during mobbing, the body was practically horizontal, the head and body jerked down to one side, the tail jerked up simultaneous with the *weet* outburst and the legs bent until the breast touched the feet; the head quickly returned to the alert, up position, but the tail only gradually sank back downward (fig. 2). Such "rocking" behavior both during mobbing and at other times of alarm was virtually identical in form with that of the Scrub Jay and was given in the same contexts, although not so frequently.

Aah and begging.—The group of calls here designated as *aah* were sometimes similar in sound to the nestling begging calls of young Scrub and other jays, sometimes a little shorter. The calls varied in length but were not as short and abrupt as the gutturals or single *weets*. In loudness they were typically between gutturals and *weets*. *Aahs* and begging were recorded in April but not in February in Madera Canyon. Various actions or displays often accompanied the calls. These typically involved gaping, lowering of the head, and flicking or fluttering of the wings, which were sometimes spread to various degrees. The degree of elaboration of these elements could be correlated in part with the context.

Simple, silent gaping by a subordinate which was reluctant to leave when a dominant landed nearby was observed several times among captives. Under similar circumstances the gaping was also sometimes accompanied by the *aah* and vibration or fluttering of the virtually fully folded wings over the back. Such behavior in similar contexts was not seen in the free-living jays.

Aahs together with some form of begging were often given by jays in brooding position on a nest. Often the *aahs* were accompanied merely by gaping, but more commonly also by flicking or fluttering of the folded wings just off the back. Sometimes these actions were clearly directed toward the mate on or near the nest, but at other times they were given in response to the sound of the approaching flock. Once a female, to whom her mate was giving courtship display, was seen giving *aahs* and fluttering her

wings closely over her back. The male had a sunflower seed in his bill. Such behavior on the part of the female was also seen only rarely during courtship display in the Steller and Scrub jays.

The circumstance in which *aahs* and begging were most frequently observed in Madera Canyon was in response to other jays attempting to rob the nest of the displaying jay. These jays usually sank down low in the nest with the gape just showing over the edge, quivered their wings slightly to vigorously without spreading them, gaped widely at the robber, and gave *aahs*. Meanwhile the intruder sometimes jabbed and pecked the displaying bird severely.

The context in which the display was most fully developed was in begging for food. On five occasions a subordinate, captive female and once a subordinate, free-living male jay were seen calling *aahs* and displaying with partly to fully outstretched, fluttering wings to dominant jays carrying food in their bills. Such complete extension of the wings during this display was not observed at any other time.

Bill-raising.—Threat displays given toward Mexican Jays or other species were conspicuously absent both in Madera Canyon and in the captives. Swarth (1904:30) described a display given toward a rattlesnake and by a captive when "angered" in which the head and body were "bolt upright, and tail pressed down on the ground. . . ." This display appears to be similar to the bill-raising which was given commonly by male hand-reared and wild Scrub Jays toward their mates. Mild bill-raising was occasionally seen in the captive Mexican Jays.

Courtship.—Despite almost continuous observation from sunrise to sunset for nine days in April and May at the time of egg laying, courtship display of Mexican Jays was observed only four times. In captivity only the initial stages of courtship were observed. Coition was not seen at any time.

Where identity was known, the participating pairs were adults in three cases, and the active role was taken once by a male and once by a female. Three of the observations were made between 6:33 and 8:10 in the morning and one at 4:00 p.m. The display was seen three times on the ground and once in a tree.

In Steller and Scrub jays, the usual courtship pattern consists of the male circling the female about six inches away with his wings and tail spread and their upper surfaces turned toward the female. This is followed by sidling toward the female with occasional probes of the male's bill toward the female and repeated 180° reversals of orientation to the female. It culminates in mounting.

Although the existence of such a pattern in the Mexican Jay could not be fully ascertained, many aspects of the observed behavior were in agreement with it. Circling was observed twice. In one of these cases the tail was moderately spread and the wings slightly spread. On the other two occasions, sidling and probing movements of the bill were seen.

The displays were different in several respects from those of Steller and Scrub jays. In the Mexican Jay the bill was in all cases held pointing conspicuously downward. The neck was once ruffled. And the belly feathers twice conspicuously fluffed out. The total effect produced a hunch-backed appearance. Another peculiarity not observed in Steller and Scrub jays was the carrying of food in the bill of the displaying jay on two of the four occasions. Song, which was typical of courting Steller and Scrub jays, was not heard during the courtship of Mexican Jays, nor did either participant assume a posture characteristic of song. No vocalizations were heard during these observations.

In captivity one male paid consistent attention to the only female, sidling up to her on two occasions. His attentions were made conspicuous by his aggressive supplanting

of either of the other two males whenever one landed near the female. The female often sang during this period, which lasted only a few days.

Bill-rapping was seen on two occasions in a captive male to whose courtship attempts the female did not respond. This male had been unusually aggressive with the female and other males. Bill-rapping in the wild population was never observed, not even while the author was inspecting nests, an activity which frequently elicited bill-rapping in Steller and Scrub jays.

In Madera Canyon courtship feeding was seen only once off the nest but nine times on the nest. When the individuals were identified, the feeder was eight times the male mate and once a female. This female, which had lost her clutch of 5 eggs two days before, was feeding another female on the latter's nest.

Hardy (1961) also found courtship feeding away from the nest during the pre-incubation phase to be rare, and Gross (1949) did not report it. The Mexican Jay, therefore, appears to differ in this respect from Scrub, Blue, and Steller jays, in which courtship feeding may be observed frequently away from the nest during the pre-incubation phase. Such feeding cannot serve merely to nourish a female confined to the nest. The less frequent occurrence of courtship feeding in the Mexican Jay than in other species of jays studied is correlated with its relatively weaker pair bond (as judged by the lesser role of the pair in reproduction and territoriality). This suggests that courtship feeding is involved in the maintenance of the pair bond.

In captivity one male was observed feeding other jays 15 times. Twelve times the recipient was a female Mexican Jay, twice a female Scrub Jay, and once a male Scrub Jay. In transferring food the female Mexican Jay typically lowered her head and the male turned his head so that the upper and lower mandibles of each bird would not all be in the same plane. In the group of captives studied by Hardy (1961), a female frequently fed a male which was lower than she in the dominance hierarchy.

Interspecific relationships.—Because intraspecific aggressiveness of Mexican Jays was found to be markedly less than in other species of jays, the question arises whether their aggressiveness toward other species is also less. In this study Mexican Jays were observed mobbing a bobcat, a mounted Screech Owl, a museum skin of a Great Horned Owl, and in captivity a live Great Horned Owl and a gopher snake. Swarth (1904) mentioned the mobbing of fox, bobcat, and rattlesnake; Brandt (1951) mentioned mobbing of skunk, rattlesnake, and horned owl; and Marshall (1957) reported mobbing of a gray fox (*Urocyon cinereoargenteus*). Species observed being chased, supplanted, or otherwise dominated include Steller Jay and Acorn Woodpecker, in the present study, and juncos, towhees, grosbeaks, and a flicker (Gross, 1949). Species observed dominating, chasing, or supplanting Mexican Jays in Madera Canyon include White-winged Dove, *Zenaida asiatica* (Gross, 1949), Acorn Woodpecker, and Red-shafted Flicker (*Colaptes cafer*). Several observations of the robbing of eggs and young from the nests of other species were made by Gross (1949). Therefore, in respect to mobbing of predators, dominance relations with other species, and the robbing of nests of other species, the Mexican Jay appears not to be noticeably different from other species of jays.

Because it is larger than Steller and Scrub jays, the Mexican Jay might be expected to be dominant to these species. Dominance over the Steller Jay was observed on three occasions in February in Madera Canyon and on many occasions in captivity. Dominance relationships with wild Scrub Jays were not observed. When a pair of hand-raised Scrub Jays was kept with a pair of wild-caught Mexican Jays, the male Mexican Jay supplanted the male Scrub Jay seven times and was himself supplanted by the Scrub Jay

only once from June 12 through September 10, 1959. But from September 16 through 28, 1959, the male Scrub Jay supplanted the male Mexican Jay 75 times with no reversals. The reversal in dominance was associated with active pursuing and continual supplanting of the Mexican Jay on the first day with 35 supplantings of the Mexican Jay by the Scrub Jay within the half-hour observation period. On the day of dominance reversal, the jays were given acorns for the first time that autumn, and the flurry of storage activity by the Scrub Jay and the possessiveness associated with it seemed to be related to his increased aggressiveness. No such response to the acorns was seen in the Mexican Jays.

The female Mexican Jay during the same period was supplanted by the male and female Scrub Jays 24 and 93 times, respectively, as opposed to only four supplantings by the female Mexican Jay of the male Scrub Jay and none of the female. The Scrub Jays in addition to being more aggressive were conspicuously more active in other respects than were the Mexican Jays.

In Madera Canyon Steller Jays frequently foraged within the flock of Mexican Jays, but such incidents seemed to be due to chance or the utilization of a common food source. When the flock traveled on, the Steller Jays were usually left behind or flew in another direction. Similar observations and conclusions were made by Swarth (1904) in respect to both Steller and Scrub jays.

Although Mexican Jays entered traps with relatively little hesitation, Steller Jays were never trapped in the same area despite their continual presence around the traps. Swarth (*op. cit.*) noted that Mexican Jays were more curious than the Scrub Jays coexisting with them.

BEHAVIOR, SOCIAL ORGANIZATION, AND EVOLUTION

A comparison of *Aphelocoma ultramarina* with *A. coerulescens* gives some insight into the evolution of behavior and social organization in these species. When some of the behavioral, morphological, and ontogenetic differences between these populations are considered, a pattern may be seen in which the Scrub Jay and the Arizona population of the Mexican Jay are extremes and the Texas population of the Mexican Jay intermediate. The Arizona and Texas populations, although only about 400 miles apart geographically, are actually the two extremes of a series of populations extending in a U-shape curve through the mountains of México, perhaps over 1000 miles (Pitelka, 1951). An outline of the differences discussed below is presented in table 7.

The most conspicuous behavioral differences between the Scrub Jay and the Arizona populations of the Mexican Jay are in their social organizations and the aggressiveness and gregariousness which underlie them. In the Scrub Jay, available habitat is divided into areas in each of which a pair of jays is dominant over all other jays the whole year; these areas are strongly defended, especially in the breeding season. The chases, vocalizations, and general behavior of Scrub Jays in defense of these areas are very conspicuous, and I know of no North American or European species of jay in which defense of living space is more extreme. In the Arizona form of the Mexican Jay, available habitat is divided into areas in each of which a group of jays lives the year around and which are probably defended against other individuals and groups. Most unusual even in communal species of birds is the virtual absence of intraspecific defense of the nest itself. Such weakly developed defense of nest and living space has not been reported for any other species of jay, although the Piñon Jay deserves investigation in this respect because of its extreme gregariousness. Thus, within the genus *Aphelocoma* two opposite extremes exist in respect to defense of nest and living space.

The basic difference in aggressiveness can be correlated with a number of other behavioral differences between the species. (1) The absence of the rattle call from the Mexican Jays in Arizona is in agreement with that population's lack of aggressiveness.

TABLE 7

A COMPARISON OF ARIZONA AND TEXAS POPULATIONS OF *Aphelocoma ultramarina* WITH *A. coerulescens*

Mexican Jay in Arizona	Mexican Jay in Texas	Scrub Jay (Berkeley)
Social organization		
Gregarious; in flocks of 8–14 or more throughout the year; probably with year-round "territories."	Gregarious; in flocks up to 12 (Brandt, 1940).	Pairs with year-round "territories"; flocks of young birds in autumn.
Pairs at nests with occasional help from other flock members.	Pairs at nests (Van Tyne and Sutton, 1937); help from other flock members not reported.	Pairs at nests exclusively.
Behavior		
Aggressiveness inconspicuous and minimal; "territory" defense rare.		Aggressiveness conspicuous and extreme; territory defense continual.
"Individual distance" 2 inches or less.		"Individual distance" about 12 inches.
Rattle call apparently absent.	Rattle call present (Van Tyne, 1929; Brandt, 1940).	Rattle call present.
Bill-rapping and threat displays relatively rare.		Bill-rapping and threat displays relatively common.
Basic call *weet*, often in rapid phrases, highly variable.	Basic call *oint-oint-oint*, much different from Arizona jays, delivered more slowly and evenly in a high pitch (Brandt, 1940).	Basic calls *scree, whew,* more stereotyped than in Mexican Jays in Arizona.
Morphology		
Plumage more uniform, less contrasting, duller.	Plumage brighter, richer blue than Arizona jays on head, rump, wings, and tail; gray-brown of back darker, more contrasting; throat whiter, more contrasting (Van Tyne and Sutton, 1937). Plumage differs from Arizona jays in direction of Scrub Jay.	Plumage bright, rich blue on head, rump, wings, tail; white throat and brown back contrast strongly with blue; conspicuous "necklace."
Size, largest.	Size, intermediate.	Size, smallest.
Eggs "unique among jays' eggs in being entirely unspotted" (Bent, 1946:120).	Eggs "dotted with dark, greenish spots . . . closely resembling the eggs of the California Jay group" (Brandt, 1940:74).	Eggs spotted.
Ontogeny		
Bill conspicuously blotched with light areas in first-year birds and even in some adults.	Bill entirely black soon after leaving nest (Van Tyne and Sutton, 1937).	Bill entirely black soon after leaving nest.
Number of retained juvenal greater secondary coverts relatively many (Pitelka, 1945).	Number of retained juvenal greater secondary coverts intermediate (Pitelka, 1945).	Number of retained juvenal greater secondary coverts relatively few (Pitelka, 1945).

The rattle in the Scrub Jay was observed to be given exclusively by females and most frequently during territory defense. In the Steller Jay it was also given exclusively by females and was the call most frequently followed by attacks. Thus, it is a call closely associated with aggressive behavior of females in the latter two species.

(2) The reduction of "individual distance" in the Mexican Jay to the point where several jays may feed together on the same food item sometimes in contact with each other is in keeping with the low degree of aggressiveness and with foraging and feeding in flocks characteristic of the species. Such behavior has never been observed in the Scrub Jay, even in the autumn and winter flocks of first-year birds; on the contrary the aggressiveness of the flock members keeps them at the least 10 to 12 inches apart.

(3) Bill-rapping and threat displays were commonly observed in the Scrub Jay but very rarely in the Mexican Jay. Both of these were associated with aggressiveness in the Scrub Jay.

(4) In quickness of activity, and in length of activity periods in captivity, the Scrub Jay exceeded the Mexican Jay. In nature the rapidity of action and ease of excitability of individual Scrub Jays appeared greater than in the Mexican Jay.

There is some evidence that the behavior involved in courtship and in the maintenance of the pair bond occurs more frequently in the Scrub Jay than in the Mexican Jay. Courtship feeding off the nest during the pre-incubation (or courtship) period was also noticeably commoner in the Scrub Jay than in the Mexican Jay. (The males of both species commonly fed the incubating or brooding females on the nest.)

Little is known of the behavior and social organization of the population of Mexican Jays in Texas. They are reported to live in groups similar in size to those of the Arizona population (Brandt, 1940), but nothing is known concerning intraspecific defense of nest and living space. Because they possess the rattle call, Texas individuals may be more aggressive than Arizona individuals. But they would probably be less aggressive than Scrub Jays judging from their habit of group living. Other differences in voice (table 7) are more difficult to evaluate.

In several non-behavioral characters the Texas population of the Mexican Jay is intermediate between the Arizona population and the Scrub Jay. In plumage it is more differentiated in the direction of the Scrub Jay than is the Arizona population. The blue areas are brighter and richer; the gray-brown of the back darker, the throat whiter and the plumage in general more contrasting. In size the Texas individuals are smaller than those in Arizona. In coloration of eggs and in adult bill coloration the Texas population resembles the Scrub Jay rather than the Arizona population. Thus, the Texas population of *A. ultramarina* would appear to differ from the Arizona population of the same species in the direction of the Scrub Jay, *A. coerulescens,* in behavioral and morphological characters.

A correlation between aggressiveness and certain behavioral and morphological characters within the genus *Aphelocoma* may be made on the basis of the above information. The lesser importance of aggressiveness in the Arizona population of the Mexican Jay as compared to the Scrub Jay is associated with an increase in the role of the flock in reproductive activities, foraging, and territoriality, a decrease in "individual distance," less intense activity, lowered excitability, loss of the rattle, less frequent use of bill rapping and threat behavior, less striking plumage, larger size, and unspotted eggs.

A hint concerning the evolutionary processes which coordinate parallel changes in the preceding complex of characters may be gained by considering differences in rate of maturation. Like the Scrub Jay, Texas individuals of the Mexican Jay acquire black bill coloration soon after leaving the nest (Van Tyne and Sutton, 1937). In contrast

Arizona individuals of the Mexican Jay may require more than three years to reach the same condition, but birds with subadult coloration of the bill may, nevertheless, take part in normal nesting activity with development of brood patch and swollen cloacal protuberance indistinguishable from those of black-billed adults. In the number of juvenal secondary coverts retained during the postjuvenal molt the Arizona population averages highest, the Texas population intermediate and the Scrub Jay lowest (Pitelka, 1945). Other characters of the Arizona jays which are ordinarily associated with immaturity in jays are their gregariousness, relative lack of defense of nest and living space, and duller, less contrasty plumage.

In addition, there is evidence of a difference between the two species in age of reproductive maturation. In the course of examining many specimens of both species Pitelka (personal communication) found that first-year jays in breeding condition were virtually unrepresented in the Mexican Jay sample although fairly common in the Scrub Jay. In this study first-year Arizona jays were not observed breeding; and Hardy (1961) and Gross (1949) observed that jays with blotched bill coloration were not breeding.

These facts suggest that the evolution of the unusual social organization and accompanying behavior characteristic of the Mexican Jay in Arizona was associated with retardation in the rates of maturation of a number of somatic characters. Conversely, evolutionary change in the direction of the Scrub Jay may have involved acceleration of rates of maturation of these characters. Thus, in *Aphelocoma* evolutionary changes in aggressiveness, social organization, and spacing appear to be related to a variety of morphological changes; and all of these types of change appear to be integrated through basic changes in maturational rates.

Consideration of the role of ontogeny in social organization permits one to view the problem of the adaptive value of territoriality in better perspective. Lying between the final social organization and spacing pattern of a species and the initial selective pressures imposed by the environment are the ontogeny and behavior which create the social organization.

Largely through the development and continuation of aggressiveness and/or gregariousness in individuals the spacing pattern of the population is achieved and maintained. Genetic changes effecting evolutionary changes in spacing are, therefore, probably first manifest in aggressiveness and gregariousness at the level of the individual. For it is difficult to envision how important genetic changes which are not advantageous to individuals can spread through a large population. Therefore, the immediate advantage of typical territoriality is probably a richer supply of resources or other advantages for the individual, rather than the derivative, population phenomenon of spacing as such. The contrary view maintained by Johnston (1961:388) that "spacing . . . is the immediate adaptive advantage of territoriality" bypasses the fact that spacing is the result of the ontogeny and activities of individuals.

The balances of selective forces acting on individual Mexican and Scrub jays to maintain their respective types of spacing are difficult to conceive. Presumably some aspects of their environments make the pair-in-territory type of spacing more successful in the Scrub Jay and the flock-in-territory type more successful in the Mexican Jay. Teleologically, it would appear that the advantages to the individual Mexican Jay of reserving a territory for himself are outweighed by the advantages gained through flock membership.

Some hypothetical advantages to the individual of the flock-unit as opposed to the pair-unit in the specific habitat of the Mexican Jay might be: (1) holding of a larger, richer, and more varied territory with less energy expenditure through the participation

of the whole flock in its defense, (2) greater efficiency of the flock in foraging for food, and (3) greater efficiency of the flock in the discovery and routing of predators. These and other hypotheses still require investigation.

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SUMMARY

The composition and activities of color-banded flocks of Mexican Jays were studied in Arizona during the winter and spring of 1958. The size of flocks encountered in the field varied within a relatively narrow range compared to other species of jays. All of the seven jays with subadult bill coloration in April which were in their second year or older were breeding, but none of five first-year jays was breeding. Flock composition was virtually constant in April and May but moderately variable in February. Individuals of adjoining flocks did not intermix except under exceptional circumstances. Although mutually exclusive flock areas were maintained in both winter and spring, few signs of defense of a flock territory were observed. An unusual degree of communal participation in the affairs of some nests existed but primary responsibility for each of the seven nests observed lay with a specific pair. Nest lining was stolen in the majority of 56 observed visits to nests by non-owners. Stage of nesting cycle in three flocks was inversely correlated with elevation.

The behavior of the Mexican Jay was found to be similar to that of the congeneric Scrub Jay in respect to song, guttural call, and stereotyped movements of foraging, food handling, and storage. The aggressive rattle call of the Scrub Jay was apparently absent, and bill-rapping and threat behavior were less frequently observed in the Mexican Jay. The vocalizations and stereotyped actions of the species are described together with the contexts in which they were observed.

Within the genus *Aphelocoma* the lesser importance of aggressiveness in the Arizona population of the Mexican Jay as compared with the Scrub Jay is associated behaviorally with an increased role of the flock, less conspicuous territoriality, less intense general activity and excitability, less frequent use of the rattle, bill-rapping, and other threat behavior; it is associated morphologically with less striking plumage, larger size, and delayed attainment of adult bill coloration and plumage. It is suggested that in *Aphelocoma* basic modifications in ontogenetic rates may have integrated the evolutionary changes responsible for most of these differences.

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