

THE WINTER SOCIETY OF THE OREGON JUNCO: THE FLOCK

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The Oregon Juncos (*Junco oreganus*) of the present study were wild, free-living birds, color-marked, and observed for the most part at two feeding stations, one in the Deep Springs basin in Inyo County, California, and one in Seattle, Washington.

The Deep Springs basin, which is surrounded by parts of the White and Inyo mountains, has an elevation of 5000 feet and is about fourteen miles long by four miles wide. It has no settlement except the Deep Springs School, which operates a cattle ranch and has about 150 acres under cultivation. Lines of large cottonwoods follow the irrigation ditches. Lawns, deciduous trees, and shrubs partly surround the buildings. About 25 feet away from the feeding station a belt of fifteen deciduous trees separated it from the low desert vegetation of the basin as a whole and furnished perching places.

In Seattle the feeding station was in a residential area but was about 300 feet from a heavily wooded section to the north and about 200 feet from a narrow strip of woods to the east. Connecting this wooded strip with the feeding station area was a vacant lot covered with weedy hummocks and heaps of stones and brush. This lot had nine large conifers. There was also a line of trees, largely conifers, running along the back lot lines of the houses in the block.

Canary grass seed and chick feed were the foods provided. The feeding stations were strips of ground twelve feet by four, running parallel with and about six feet from the wall of the house, centered on a window, and bordered on the ends and outer side by heaps of brush from three to seven feet high, in which the birds perched, rested, and took cover. Being indoors the observer was able to make prolonged day-to-day observations regardless of weather. At Deep Springs, 435 hours were spent at the post of observation between October 24, 1948, and January 25, 1949. Observations were resumed on February 20 and totalled about 50 hours before the departure of the birds in March. In Seattle 365 hours were spent in observation between December 28, 1949, and April 3, 1950.

The birds were marked by cementing (with Duco) one or two trout-fly feathers to the top pair of tail feathers close to the body. These markers were durable and varied naturally in shape, texture, and the curve of the shaft, as well as in color. They were trimmed if necessary to about the length of the tail and were cemented to it wrong side up, to be made more readily recognizable by the upward curve of the shaft away from the tail. The markers were conspicuous but did not seem to be noticed either by the wearer or its fellows. When eating in a high wind the marked birds had a little more difficulty with their footing than the unmarked ones, but not to a serious extent. The birds were easily distinguishable as individuals. Marked individuals were named with letter symbols by assigning a different letter to each type of feather; B stood for blue, N for black, and so on. This system brought the name of the bird instantly to mind, a crucial point in observations which rely on the correct identification of swift-moving little birds. Furthermore, the relative positions of the feeding station and the observer were such as to bring the birds within a range of about six to fifteen feet. For observations outside the station binoculars were used as needed.

The observer at a feeding station cannot choose his material. Not knowing which species would prove useful, the writer marked every bird trapped, with the resultant discovery that the juncos formed the only stable visiting group. At Deep Springs 239 birds of eight species were marked, including 120 juncos. One vagrant Tree Sparrow

(*Spizella arborea*) was included. Linnets (*Carpodacus mexicanus*) were irregular and infrequent. The White-crowns (*Zonotrichia leucophrys*) marked in the fall were of the Gambel type and seemed to be migrants; in January three occasional visitors not of the Gambel type were marked and identified as belonging to a winter group resident elsewhere on the ranch. In March White-crowns again visited the station in what may have been a first premigratory move (Linsdale, 1949), since some marked individuals were present for several weeks. These spring migrants included both types. One of these birds had been marked in October. The first-marked Lincoln Sparrows (*Melospiza lincolni*) also stayed for two or three weeks, as if they were premigratory. Chipping Sparrows (*Spizella passerina*) were fall migrants, and American Goldfinches (*Spinus tristis*) disappeared in December. Brewer Blackbirds (*Euphagus cyanocephalus*) usually flocked in the pastures but came irregularly to the feeding station, driven by hunger after snow covered the ground.

In Seattle heavy snow in January brought Song Sparrows (*Melospiza melodia*) to the station for about four weeks. Thirteen of these birds were marked. Otherwise juncos, of which 33 were marked, were the only visiting birds.

The time spent in marking these transient or irregular birds was not entirely wasted. They provided contrasts in social behavior which tended to sharpen the perception of details in junco behavior.

It is possible that the junco is a steadier visitor than other species at a feeding station, and therefore a more satisfactory object of study, because a fixed feeding spot fits into its normal routine. Persistent return to definite spots seems to be characteristic of its winter behavior. It seems also to be the case that, as the migrants arrive, the population tends to divide for the winter into small flocks of stable membership. Within this social structure two mutually limiting tendencies appear. The winter residents are gregarious but they are also intolerant of the close proximity of fellow members of the species. The limits of tolerable proximity are elastic and vary with environmental conditions, but a reaction of intolerance may be said to be released by a second bird which is tending in one way or another to invade the area of privacy which the reacting individual maintains about itself. A subordinate bird may show its intolerance by avoiding a dominant bird; the latter shows its intolerance by pecking at, or otherwise gesturing at, the subordinate. A straight-line pecking order emerges when these relations are recorded (Sabine, MS).

Gregariousness and intolerance function together in the winter society of the species. It is the object of the present paper to report what was learned about the gregariousness or flocking in the society. A previous study of the Slate-colored Junco (*Junco hyemalis*) had indicated that some elements of a pattern could be traced in the winter flocking of that species (Sabine, 1949).

THE FLOCK AT DEEP SPRINGS

It was anticipated that part of the birds marked would turn out to be migratory and part winter resident. It seemed possible that the two classes would not be overtly distinct in behavior and yet that there might be a tendency for them to separate. Quantitative observations were sought which, when analysed after the transients had identified themselves by vanishing, might throw some light on this point. A start was made on October 30, 1948, by noting the names of the marked birds together with their groupings, but only part of the time was devoted to this; some time was given to the observation of dominance relations. On November 3 priority was given to censusing. The time of arrival at the feeding station and the names of the marked birds were noted for

each group. Unmarked juncos usually accompanied the marked birds. On November 5 a count of the unmarked birds was added to the census, which was kept up through November 29. The figures of this census provided information on a number of points not thought of when it was undertaken and are drawn on heavily in what follows.

Table 1
Assembly of the Color-marked Winter Resident Flock

Date	Number marked, including transients	Number of residents marked	Names of winter residents		
			Station flock	Other flocks	
Oct. 24	3	1	BG		
25	0	0			
26	7	1	CR		Note 1
27	5	2	NO, AG		
28	7	3	RN, GR, X		
29	2	0			
30	1	0			
31	2	0			
Nov. 1	1	0			Note 2
2	1	0			Note 3
3	4	0			
4	2	0			
5	0	0			
6	0	0			
7	3	1	PS		Note 4
8	2	0			Note 5
9	5	3	OC, CZ	BD	Note 6
10	7	2	AD, ND		Note 7
11	----	----			
12	7	3	SA, OG	NC	Note 8
13	5	3	RS, YJ	AT	
14	0	0			
15	0	0			Note 9
16	2	1	AB		Note 10
17	0	0			
18	----	----			Note 11
19	----	----			
20	6	6	CB, R, O, G, CT	B	Note 12
21	2	2	Y, NJ		
22	1	1	LJ		
23	0	0			
24	----	----			
25	1	1	JG		
26	2	2	JO, JD		Note 13
27	1	1	OB		
28	2	2	AO	RA	
29	0	0			
Totals	81	35	30	5	

The assembly of the flock.—On October 2, 1948, the piles of brush for the feeding station, which was surrounded by sand and clumps of Russian thistle, were put in place. On October 16 the first junco, a solitary bird, was sighted lurking in one of these clumps and appearing to watch the white-crowns and linnets already feeding at the station. During the next two days a single junco was sighted in cover a number of times. Then two were sighted and thereafter numbers increased gradually. The birds continued to

lurk under cover, small numbers alighting, departing, and returning at intervals. This process continued for eight days. From subsequent observations it seems probable that some of these individuals were repeaters. On October 24 the juncos first visited the station in small numbers, and the procedure of trapping and marking began.

The lapse of eight days during which juncos visited the neighborhood and watched but did not enter the feeding station is open to the interpretation that during the first period of winter residence a process of familiarization was taking place. Some later events also suggested this theory.

Between October 24 and November 29, 81 juncos were color-marked. Of the 81, 35 proved to be winter residents (table 1). The 46 remaining birds were transient and for the most part probably visitors which were en route in migration. Their daily visits at the station had distinctive aspects when viewed against the knowledge of the residents; these differences will be described in a later section of the paper.

Of the 35 winter residents, five were casual visitors at the station. They were trapped and marked there but revisited infrequently and were later identified as members of a different flock (table 1, col. 5).

The resident flock (col. 4) falls into three groups separated by lapses of time when no new winter residents were taken (October 29–November 6) or only a single bird was captured (November 14–19). The reason for these lapses seemed to lie in the fact that

Table 2
Number of Birds and Number of Visits, November 3–29*

Date	Hours of observation	Residents		Transients		Unmarked	
		Number of visits	Number of birds	Number of visits	Number of birds	Number of visits	Number of birds, calculated
Nov. 3	3	12	6	30	6		
4	4½	30	6	51	9		
5	7	36	6	46	7	72	11.4
6	4	19	6	19	4	50	13.1
7	4¾	21	6	29	4	64	12.8
8	4¾	39	7	37	4	120	17.3
9	7¾	70	9	88	6	163	15.4
10	5	52	10	42	7	99	18.0
12	5	50	12	32	8	119	29.0
13	6½	86	14	81	9	82	11.2
14	4½	59	15	37	7	45	10.3
15	8	119	16	46	4	75	9.0
16	7½	124	17	33	3	94	12.0
17	7	116	17	19	2	75	10.5
18	3	56	17			32	9.7
19	3	49	16			33	10.7
20	4¾	106	20			92	17.0
21	6½	257	25			113	11.0
22	3	102	22			52	11.0
23	4	132	24			49	9.0
24	4½	168	24			66	9.4
25	4	208	24			73	8.4
26	5½	233	27			86	10.0
27	4½	156	27			61	10.5
28	5½	176	28			44	7.0
29	2	92	28			34	10.3

* More than 50 per cent of the newly marked birds had unusually low visiting records on the day they were marked, either reappearing once or not at all. It is probable that they suffered shock from the trapping and marking procedure. Their records on those days were excluded from table 2.

the stream of migratory birds was subject to fluctuations, and that trapping was most successful in the periods of fresh invasions of new birds. There were three reasons for the supposition that swelling and subsidence of numbers occurred in the migratory stream as seen at the station.

1. The census recorded the numbers of marked birds, transients and residents, seen each day (table 2, col. 4 and 6), and the numbers of visits of unmarked birds counted (col. 7). It is assumed that the ratio of the number of marked birds to the number of their visits (col. 3 and 5) on any day will equal the ratio of the unknown number of unmarked birds to the known number of their visits. Table 2, column 8, gives the result of this computation. It appears that the unmarked birds visited the station in their largest numbers from November 8 to 12 (15.4–29 birds) and again on November 20 (17 birds).

2. During observations, the observer noted at times that there were unusual numbers of unmarked birds about, the basis for these impressions being that unmarked birds were seen in larger groups than was usual. After the figures of the census were tabulated, it appeared that groups of more than four or five unmarked birds were actually rare. The census recorded 496 groups of unmarked birds between November 5 and November 29. Their distribution as to size was as follows:

Size of group	1-5	6	7	8	9	10	11	12	13	14
Times seen	419	37	22	7	5	1	1	2	1	1

Groups of eight birds or more were seen only eighteen times. It will be noted later that the incidence of most of these eighteen groups coincided with the dates when the largest number of unmarked birds (as calculated from the totals of their visits) appeared at the station.

3. On five mornings at dawn there were signs of a new invasion. It was routine practice to take a brief look at dawn, which turned out to be the moment when the marked flock gathered in the largest group of the day. On November 2, 8, 10, 12, and 16 the flock foraging inside the station was accompanied by relatively large numbers of unmarked birds on the clumps of Russian thistle outside. The light was too dim and their numbers too large for accurate counting but it was estimated on different mornings that they ran from 20 to 40.

Some of these indications of fresh arrivals were noted also in the pre-census period. For convenience of reference the dates at which probable fresh arrivals were observed have been marked with a note in the right-hand column of table 1. Each such insertion means that on the date in question some or all of the indications of fresh arrivals just described were seen. These waves of fresh arrivals to which the notes refer coincided as a rule with success in trapping (table 1, col. 2), and particularly with the trapping of the winter resident birds (col. 4 and 5). The occurrences to which the notes refer are described below.

Note 1 (October 26). A sudden increase occurred in the number of juncos and 16 were counted in a single group. On or closely following this date 19 birds were trapped (table 1, col. 2) and 6 resident birds were marked (col. 4).

Notes 2 and 3 (November 1 and 2). On November 1 the notebook mentioned twice that "unusually large" groups of unmarked birds were being seen. On November 2 there was an invasion of unmarked birds at dawn, and a "large" group was mentioned later. To be consistent these occurrences should have coincided with stepped-up trapping (col. 2); but this was not the case, only one bird being captured on each of these dates. The reason, however, was obvious. Two Chipping Sparrows (*Spizella passerina*) marked the day before—the only members of their species present—occupied the trap to the exclusion of the juncos. They were completely lacking in trap-shyness. No sooner was the trap reset than one or the other entered. On November 2 they were equally persistent and

finally one was taken five miles away and released. On November 3, 4 juncos were trapped despite the fact that the remaining Chipping Sparrow was trapped eight times.

Notes 4-8 (November 7-12). Between these dates the number of migrants was probably at a maximum. There was a relatively large number of the events that have been interpreted as signifying the arrival of new birds: three invasions at dawn, eleven groups of 8 or more unmarked birds out of a total of eighteen such groups, and four of the five largest calculated numbers of unmarked birds (table 2, col. 8). Trapping success during this period was notable: 29 of the 81 marked juncos (about 36 per cent) were trapped between November 7 and 13. Twelve were winter resident birds (col. 4 and 5).

Note 4 (November 7). Groups of 11 and 14 unmarked birds were counted.

Note 5 (November 8). An invasion was visible at dawn. Groups of 8, 8, and 9 were counted. The calculated number of unmarked birds increased (table 2, col. 8).

Note 6 (November 9). A group of 9 birds was counted. The calculated number of unmarked birds continued higher than the average (table 2, col. 8).

Note 7 (November 10). An invasion was seen at dawn. Groups of 10 and 12 birds were counted. The calculated number of unmarked birds rose (col. 8).

Note 8 (November 12). An invasion was seen at dawn. Groups of 8, 9, and 13 birds were counted. The calculated number of unmarked birds rose more than 50 per cent (col. 8).

Notes 9 and 10 (November 15 and 16). A group of 12 birds was seen late in the afternoon of November 15. On November 16 there was an invasion at dawn and later two groups of 8 birds were seen. These indications of fresh arrivals were not accompanied by a marked increase in trapping; only 2 birds were captured, including 1 winter resident, on November 16.

Note 11 (November 18). A group of 8 birds was seen. Trapping was not attempted on November 18.

Note 12 (November 20). Three groups of 8, 9, and 12 birds were seen. The calculated number of unmarked birds increased (col. 8). Trapping was stepped up: 6 birds were captured.

Note 13 (November 26). A group of 9 birds was seen. Two birds were captured, both winter residents.

The events described above point to the probability that fresh arrivals of migrant birds were more numerous on certain dates than on others. Whether or not on the latter dates there were no migrants at all is not known.

Table 1 as a whole shows that other events were simultaneous with these fresh arrivals. Trapping success (col. 2), the building up of the resident winter groups (col. 3 and 4), and the incidence of fresh arrivals occurred during roughly the same periods. The implication seems to be that the birds were captured soon after their arrival, and I therefore do not hesitate to assume that trapping was relatively prompt. On this basis, 81 birds were captured on thirty-three days, but 54 (or 66 per cent), including 24 of the 35 winter residents, were captured on ten days:

October 26-28	19 birds trapped	6 winter residents
November 7-13	29	12
November 20	6	6
Totals	54	24

Table 1, column 6 shows evidence of invasions of unmarked birds on these dates except November 13, when trapping of the new group in the second period was presumably completed.

Table 1 also shows that clear declines in trapping followed success. It is understandable that more birds should be trapped when more were about, but it is not obvious why the declines in trapping should be so sharp after each migrant influx, dwindling to one or two birds daily or to none. There was no dearth of unmarked birds at any time (table 2, col. 7, 8). The declines were not accidental, due to short hours of observation. November 5, 15, and 17, for example, were among the longest days of observation

(table 2, col. 2), yet not a bird was trapped. The conjecture is offered that there were distinct individual differences in trap-wariness. Among the new arrivals, the individuals that were not trap-shy were readily captured; others required time to get used to the trap, and a remnant was never trapped (table 2, col. 7 and 8). Avoidance of the trap was an observable form of behavior. It is probable also that the marked birds learned temporarily to be trap-shy, since during the assembly of the flock (October 24–November 29) only 5 of the 30 birds in the feeding station flock were retrapped.

Relations of new arrivals to prior arrivals.—The fact that the 7 winter residents captured October 24 to 28 and the 12 captured November 7 to 13 were probably separated by intervals of nine days or more suggested that the records of these two groups might be inspected for evidence that the earlier group had some advantage in having occupied the ground first, or that the two groups tended not to mix.

It is not intended to suggest here that either group arrived as a migratory group. The possibility that birds do migrate in integrated social groups has been conjectured occasionally in the literature and was given some substance when six Slate-colored Juncos were trapped in two successive years at a Massachusetts banding station (Whittle and Fletcher, 1924). Forbush (1929) suggested that neighborhood groups might be preserved during migration. Today this suggestion would be met with reserve. The control of migratory flight is assumed to involve physiological changes in the organism including the deposition of fat, stimulated in part by environmental changes in, for example, temperature or the photoperiod (Odum and Perkinson, 1951; Wolfson, 1942, 1945, 1953), and there is the unstated assumption that these mechanisms exercise primary control, without intervention of social factors. Without more substantial evidence than Whittle and Fletcher's, one hesitates to add to this complex of mechanisms the notion that social releasers synchronize the departures of members of a group.

The inquiry into possible differences of behavior, between a group newly arrived and one that had been in residence for nine or more days, amounted to inquiring whether *J. oreganus*, in becoming a social group temporarily, takes on any of the aspects of a colonial species. Howard and Emlen (1942) remark that familiarity with the environment may be accompanied by intolerance toward intruders or dominance over them in many species. A suggestive precedent was that members of a winter flock of *J. hyemalis* were dominant over, but not distinctively intolerant of, newly arrived spring migrants (Sabine, 1949).

Distinctive dominant behavior did not appear as between the early and late groups mentioned above. The members of the early group were not more intolerant of members of the later group than of each other, nor were they dominant over them. In the pecking order the two groups were interspersed in rank from the beginning.

Since nothing was known about the process whereby the winter flock develops, and since the winter flock does not remain together as a unit, it was considered possible that the birds might tend at least at first to visit the station with members of their own group. To test this hypothesis four members of each group were selected at random and the record of each, in respect to its joint visits with each of the other seven, was compiled. Three birds (BG, CR, RN) made a few more visits with members of their own group; five birds (NO, CZ, OC, OG, YJ) made more with members of the other group. The two groups appear to have coalesced completely.

The last transient was marked November 16 and did not appear the next day. The last two to be seen appeared on November 17. It is noteworthy that in a new invasion which occurred November 20 to 28, 15 birds were trapped and all were residents (table 1). The character of this invasion makes it impossible to guess when the migra-

tory season ended. It may have been merely an accident that no transients were captured. Or it is possible that the migratory season had already ended and that the new group of residents had arrived earlier and merely moved in on the station. Later experience showed that this was not impossible. Or it might be that at the end of the season all migrants were forced to stop by unknown factors of control. If this were the case, it is an interesting speculation that the latest migrants may have been birds of the year which, having no set homing goal, tended to press on until stopped by such factors. The adult junco is a winter homing bird (Linsdale, 1949).

The stability of the flock.—The 30 winter residents (table 1, col. 4) were daily visitors at the station. It was this trait that set them apart from the five marked birds belonging to other flocks (col. 5). The latter had been captured and marked at the station but they were rare visitors. NC's complete record, for example, was as follows: marked November 12, made fourteen visits November 13 (more than any other bird for that day), made four visits December 15, and one visit December 21.

Attendance of the marked birds at the station was recorded from the beginning (October 24) to the end of the observations (April 9). On eight scattered days during this period, and between January 26 and February 19, no observations were made. After the November census was discontinued, the visits of individual birds were not counted, but a daily watch was kept for each bird until it had been recorded once. It was usual but not invariable to see every bird during the first two hours of observation.

A mark of the flock's stability was the small amount of absenteeism. After December 8 no bird of the flock failed to be present each day up to the time when it disappeared for good. Prior to and including December 8, out of 990 possible entries on the roll, 55 (5.5 per cent) were absences. Twelve birds remained until time for migration and had records of unbroken attendance for three to four and a half months. Fourteen birds were never absent from the day they were marked until they disappeared, and 5 of these were among those that remained late. Of the 12 remaining late, 11 disappeared between February 22 and March 14; the twelfth was still visiting the station with a few unmarked juncos on April 9, when observations were suspended.

Sixteen were absentees at least once. Their record was as follows:

Absent	1 day	7 birds		7 absences
	2 days	2		4
	3	2		6
	4	1	(AG)	4
	5	2	(CR, NO)	10
	8	1	(BG)	8
	16	1	(GR)	16
Total		16		55

The scattered absences of one or two days occurred largely on days when observations were short. The interesting part of this record is that which relates to the birds belonging to the earliest group. Their absences piled up shortly after their arrival (table 1), occurring with two exceptions in late October and the first two days of November. GR did not become a steady visitor at the station until November 14. If the later arrivals attached themselves to this earliest group, a process of familiarization giving rise to absenteeism might not be required.

The marked birds visited the station daily and often, but not as a unit. To illustrate their mode of visiting, November 14 is chosen as a sample and the complete census for that day is given in table 3. (The table includes also the visits of the transients; these will be discussed in a later section.) In many respects irregularity was the rule.

Table 3
The Census for November 14

Winter residents															
Time	BG	CR	NO	AG	RN	X	PS	OC	CZ	AD	ND	SA	OG	RS	YJ
9:30		CR					PS							RS	
9:36															
11:08					RN						ND				
2:55		CR			RN		PS			AD		SA	OG	RS	YJ
3:15	BG		NO				PS	OC		AD	ND	SA			YJ
3:40		CR													
3:46														RS	
3:52	BG			AG	RN	X			CZ		ND	SA			YJ
4:18															
4:30		CR		AG	RN		PS			AD				RS	YJ
4:43			NO			X		OC	CZ	AD	ND			RS	RS
4:57				AG								SA		RS	
5:05		CR										SA		RS	YJ
5:15														RS	
5:19	BG				RN	X									YJ
5:23															
5:27															
5:37															
5:43													OG		YJ
Total visits	3	5	2	3	5	3	4	2	2	4	4	5	2	8	7
Transients															
Time			PN	CD	BS	YA	TD	ZD	GS						
9:30						YA							4		
9:36						YA							4		
11:08			PN					ZD					1		
2:55			PN		BS	YA			GS				4		
3:15			PN	CD		YA	TD						5		
3:40				CD	BS			ZD					5		
3:46							TD		GS				4		
3:52													5		
4:18						YA							2		
4:30													3		
4:43								ZD					5		
4:57					BS	YA							1		
5:05					BS	YA		ZD							
5:15				CD	BS		TD						2		
5:19					BS		TD	ZD					2		
5:23					BS										
5:27				CD											
5:37				CD		YA							1		
5:43				CD	BS			ZD					1		
Total visits			3	6	8	8	4	6	2				45		

1. The timing of visits (left-hand column) shows that 3 residents made a visit at 9:30 a.m. and 2 others at 11:08. This was a long but not an unprecedented lapse of time without visits: Observations were then terminated and resumed at 2:55 p.m. Eleven groups containing winter residents then made visits between 2:55 and 5:19. At 5:43, 2 residents made a visit. There was nothing about this timing that was typical of other days; there was no discernible pattern in the timing of visits.

2. The composition of the groups changed. For example, at 2:55, 8 residents arrived together. Twenty minutes later, at 3:15, another group of 8 arrived; it included 4 of the previous group. At

3:52, thirty-seven minutes later, a group of 8 flew in and included 4 from the preceding group and 3 from the first group; 2 birds had been members of all three groups. Within the hour the entire 15 had been seen.

3. The size of the winter resident groups varied as follows:

Size of group	Number of groups
1 bird	3
2 birds	3
3	3
4	2
7	2
8	3
	16 groups

The impression gained from direct observation was that the birds must be perpetually meeting, forming groups, dispersing, and reforming. Occasionally this process might be seen at the station as members of groups timed their departures differently. But it was common also for a group to arrive and depart together.

4. The bottom line of table 3 shows the number of visits made by each bird. These vary from two to eight.

Frequency of visits and temperature.—The sum of all the visits varied from day to day. In table 4 the numbers of visits made on November 14 and on two additional dates,

Table 4

Frequency of Visits by Winter Residents on Three Days with Observation Periods of Equal Length

Date:	November 14	November 24	November 27
Hours of observation:	4½	4½	4½
Frequency of visits	Number of birds		
1			
2	4		
3	3	1	2
4	3	1	6
5	3	4	5
6		6	5
7	1	4	4
8	1	3	3
9		3	1
10			1
11			
12			
13		2	

November 24 and 27, are arranged for purposes of comparison. These dates were selected because it happened that the hours of observation were the same; hence the numbers of visits are directly comparable. A comparison of November 14 with November 24 and 27 shows that on the latter dates the birds were visiting at higher frequencies. These and similar data suggest that some external controlling factor must be at work. The idea that seemed most plausible and most susceptible of testing was that the birds were responding to changes of temperature.

Deep Springs is a reporting station for the United States Weather Bureau. The equipment for making a continuous record of temperature is not maintained there, but records of a more limited sort were available from the San Francisco office. They in-

cluded three temperature readings (Fahrenheit) daily: the maximum, the minimum, and a reading at 6 p.m. Precipitation and high winds also were reported.

The three upper graphs in figure 1 record the temperature readings from November 1 to 29. The two lower graphs record the daily average intervals between the visits of the winter residents and of the transients.

The figures on which the daily average intervals between visits are based are given in table 2. The time (in minutes) was multiplied by the number of birds, and the product was divided by the total of their visits. On November 3, for example, during three hours of observation 6 birds made twelve visits. The average interval between visits per bird was 90 minutes. Positive correlations which were statistically significant at the 0.01 level were found between the daily average intervals and each of the temperature graphs. The coefficients of correlation were as follows: minimum temperatures, + 0.751; maximum, + 0.674; 6 p.m., + 0.624. The writer is indebted to Professor LaMont C. Cole, of the Department of Zoology, Cornell University, for the computation of these coefficients. From this it is evident that juncos visit more frequently on cold days than on warm days.

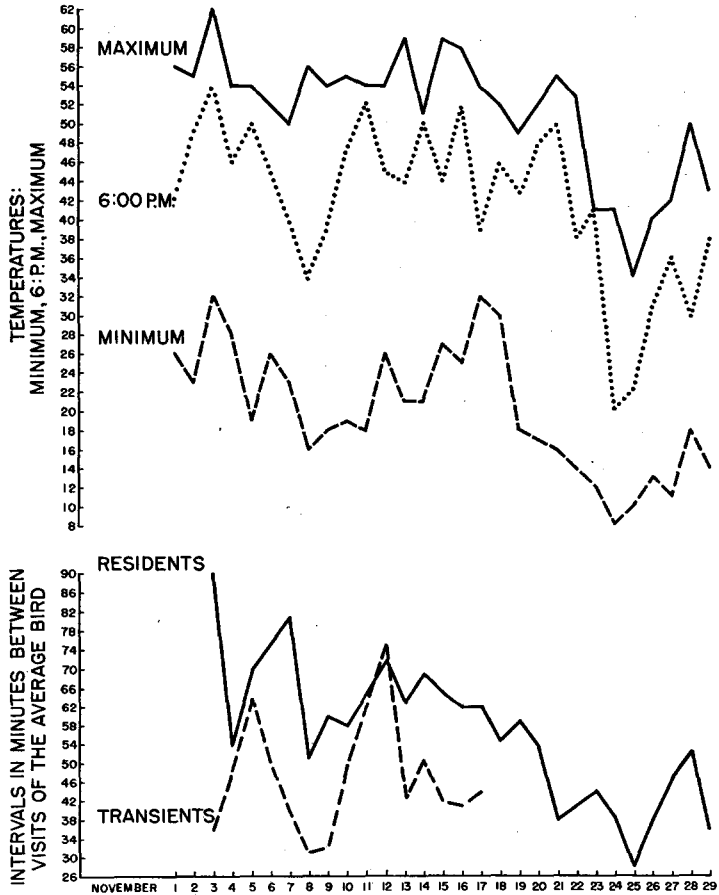


Fig. 1. Correlation of temperature with interval between visits of juncos at feeding station.

The foraging circuit.—If the feeding station flock had moved as a unit—as they at least came close to doing at dawn—they could have been regarded without further evidence as probably a “true” flock; that is, a group integrated by mechanisms which functioned to divide the junco population into such groups. The irregularities illustrated in table 3, however, raised a question about their relation to the feeding station. Was it an area of convergence away from which the marked birds scattered? Some effort was made to find other feeding places frequented either by the marked juncos or by unmarked birds. This part of the work was cut short by the severity of the winter of 1949, which put an end to outdoor observation after December 17, 1948.

Four foraging areas were discovered, or reported by members of the Deep Springs staff.

1. As soon as the earliest group was marked, marked birds were reported as repeatedly visiting an area under an isolated group of large trees. This place was visible from the residence of one of the staff members. These reports, which were made often but were not recorded by the writer, were accepted as reliable evidence that several groups of marked birds visited the place daily. One visit of these birds was watched with binoculars to verify their presence.

2. Another staff member reported that marked birds were repeatedly seen in her back yard, which was surrounded by a tall hedge. It was possible to visit this spot by driving to it and using the car as a blind. An unrecorded number of trips was made, starting November 17. On each trip a group of marked juncos appeared after an interval of half to three-quarters of an hour. On November 30 and thereafter the marked birds present were counted as follows: November 30, 7 birds; December 6, 9 birds; December 8, 16 birds; December 9, 7 birds. Each of these observations was brief, terminating as soon as one group of birds had made a visit. Nevertheless, the four groups seen included 22 of the 30 birds visiting the station.

3. A third foraging spot was discovered by selecting a likely spot and watching it. This was along the main irrigation ditch, by a dense thicket and a solitary tree. Two trips were made, each successful in sighting marked birds. On the first trip three marked birds were identified. On the second a larger number of birds flew off as the writer arrived. They were undoubtedly marked birds though not identifiable.

4. The fourth site was discovered by watching a solitary tree at the base of one of the foothills, close to the road leading to a dairy. Four trips were made and all were successful. After a period of waiting a group of juncos would arrive and forage about the tree and in the crevices between the large boulders of which the foothills are composed. The groups were as follows:

November 17—A group of unmarked juncos.

November 18—AT, BD (table 1, col. 5) and 2 unmarked birds.

November 30—AT, B, RA and a few unmarked birds.

December 6—AT, B, BD, RA and 9 unmarked birds.

These four trips made it reasonably clear that a foraging site of a different flock had been discovered, a site frequented by the four marked occasional visitors, together with unknown numbers of unmarked birds. It was as close to the feeding station as any of the three sites at which the feeding station flock had been found. The distances in all four cases were approximately 300 yards.

These observations suggest that the feeding station birds were an integrated group separate from the surrounding unmarked population. In an irregular, but nonetheless characteristic, way they flew between well defined feeding spots of which the station was one. This trait would point to the division of the population into flocks tending to be exclusive and this conjecture was supported in turn by the discovery of one feeding spot of a flock other than that at the feeding station. The second flock was fortunately identifiable by reason of its including four marked birds which had been rather rare visitors at the station. If the individual birds were integrated by being somehow restricted to a common foraging circuit, it would explain the fact that the flock had a stable membership even though the individuals seemed to have complete freedom of

movement. This seems to be the most plausible interpretation of such facts as were collected.

The unmarked minority in the winter flock.—When the migration season ended in late November, there were still unmarked birds at the station and this condition persisted throughout the winter. These birds presented a problem because I was uncertain whether they were untrapped members of the winter flock or casual visitors from other flocks. Upon continued observation it appeared that their number was relatively stable; it was estimated from day to day as about 25 per cent of the total of visiting birds. (It seems probable that this estimate was not far off. The figures for late November in table 2, columns 4 and 8, which were not available until the observations were over, support it reasonably well.) If so many were casual visitors, this threw doubt on the idea of integrated winter flocks and challenged the theory that these were distinguished by having separate foraging circuits.

When the observations were concluded, the actual performance of the five marked visitors from other flocks (table 1) provided a measure of probable behavior for such visitors, and then it no longer seemed plausible to suppose that the unmarked birds could in the main be anything but members of the station flock. The known visitors had appeared at long and irregular intervals, as will be shown in the section following. The marked birds, on the other hand, made many visits; for example, on November 26, there were 233 in 5½ hours of observation. To suppose that a third as many visits were made by irregular visitors from other flocks, which might then not appear for a week or a month, and that these were replaced by a new contingent next day, would amount to assuming the presence of a constantly changing stream of individuals. If this were the case, it is difficult to see why it was unusual to trap them. Experience during the migration season showed that fresh arrivals seemed to be followed by successful trapping. It is impossible to say how many visitors were trapped during this season because they were indistinguishable from true migrants. But during the winter only one visitor, a bird that disappeared after trapping, was captured out of 18 birds, although the trap had been set for nine days.

It also seems probable that if the unmarked birds had been visitors, there would occasionally have been visits by a large group of them. This, however, did not happen. The unmarked birds mingled with the marked in small numbers, or occasionally appeared in small groups, as would be expected if they were members of the station flock. The most likely conjecture seems to be that the unmarked birds at the station were trap-wary members of that flock.

The reduction of the flock.—The heavy loss in marked birds, whose numbers gradually fell from 30 to 12, might be interpreted as due to instability in the composition of the flock or to dispersal in midwinter. (Similar losses reduced the dairy flock from 20 to 8.) However, four losses were known to be due to illness, exhaustion, or exposure, and predators were unquestionably an important cause of losses. Early in January a Loggerhead Shrike (*Lanius ludovicianus*) and two half-wild ranch cats began to besiege the station. The losses in marked birds for three weeks were at about the rate of one bird per day but ceased after these predators were shot. There were certainly other predators, also. One bird was taken by a predator perching nearby—probably a Sparrow Hawk (*Falco sparverius*)—as it was released after being marked. In view of these known losses, it does not appear that the reduction of the flock was a reason for doubting its stability.

The amalgamation of two flocks.—About 8:00 a.m. on December 7 the feeding station was visited by 17 unmarked birds. For the remainder of the day and subsequently

the estimated percentage of unmarked birds rose sharply and remained the same, showing that the invasion had not been a momentary affair. Estimates of unmarked birds, which flew in with marked birds, were "at least half" or "probably more than half."

There was also an addition to the marked birds. The four marked birds seen at the dairy site the day before (December 6) began making daily frequent visits to the station and continued to do so. It seemed necessary, after the lapse of a few days, to accept as a fact the idea that the dairy flock had moved in, at least at the station, with the station flock.

The rise in the percentage of unmarked birds was unquestionable, and also a change in the behavior of the four marked birds of the dairy flock. These birds had been rare visitors at the station, if compared with the flock members. Their record before December 7 follows:

BD	November 9–December 6	4 visits
AT	November 13–December 6	11
B	November 20–December 6	3
RA	November 28–December 6	6

At the same period, for the fourteen days from November 16 to 29, inclusive, 15 members of the station flock averaged 87 visits each. From December 7 on, the four birds from the dairy flock came as frequently as the other marked birds. It seemed reasonable to regard them as "indicators," signifying that the newcomers on December 7 really were the dairy flock.

Accordingly it became of interest to know whether these "indicator" birds visited the feeding station only, or whether they visited also the other sites in the foraging circuit of the station flock. On December 8 three of the four "indicators" were seen at one of these sites with 13 members of the station flock; and on December 9, one was seen at the same place with six of the flock. On the same date, one "indicator" was seen at the irrigation ditch site with two members of the flock. These joint visits suggest that the two flocks became completely amalgamated.

It was of interest to discover, also, whether the "indicators" continued to visit the single known site frequented by the dairy flock. Five trips were made to the site, four lasting about half an hour each and one of two hours. No juncos were seen at any time. Since an interval of two hours without a single visiting junco had not been experienced at the feeding station, this seemed to indicate that the dairy flock had abandoned this site. Further work along these lines was prevented by severe weather.

There was no sign that the original members of the station flock distinguished the new invaders with discriminatory intolerance. As occasional visitors before December 7, the marked "indicator" birds had been treated without special intolerance, and this was probably representative of the treatment of the unmarked birds after that date. Fragmentary indications of rank in the pecking order showed that the newcomers were not uniformly subordinate to the members of the flock; RA was dominant to a large number of them but AT seemed to be subordinate to all. When the pecking order was worked out later, these relations held.

The trapping of the new flock was postponed because the observer was reluctant to add to the 27 marked birds already present until dominance relations among these 27 had been more reliably ascertained. The visits of the "indicators" and the estimated percentage of unmarked birds were constantly checked, and they remained unchanged for three weeks. On December 28 trapping was started and it revealed the characteristic trapping pattern of the assembly period: seven birds were captured the first day and one or two daily thereafter for nine days. Eighteen birds were marked; of these one was never seen again and one was a crippled bird found dead a few days later. Thereafter

the percentage of unmarked birds returned to the former 25 per cent, indicating that the dairy flock also had its quota of untrapped birds.

The daily record of the dairy flock showed the same unbroken attendance characteristic of the station flock. Eight of the 20 survived to migrate. During the migration season in March, one of the dairy flock was not seen for three days, then reappeared for three days, then vanished, an exception to the rule that every bird was seen daily.

So far as could be seen, the coalescence of these two flocks was immediate and complete. It suggests comparison with the original assembly of the flock and the immediate coalescence of newly arrived migrants with birds already on the spot. In this species it appears that a newcomer releases no hostile reaction from members of a group which

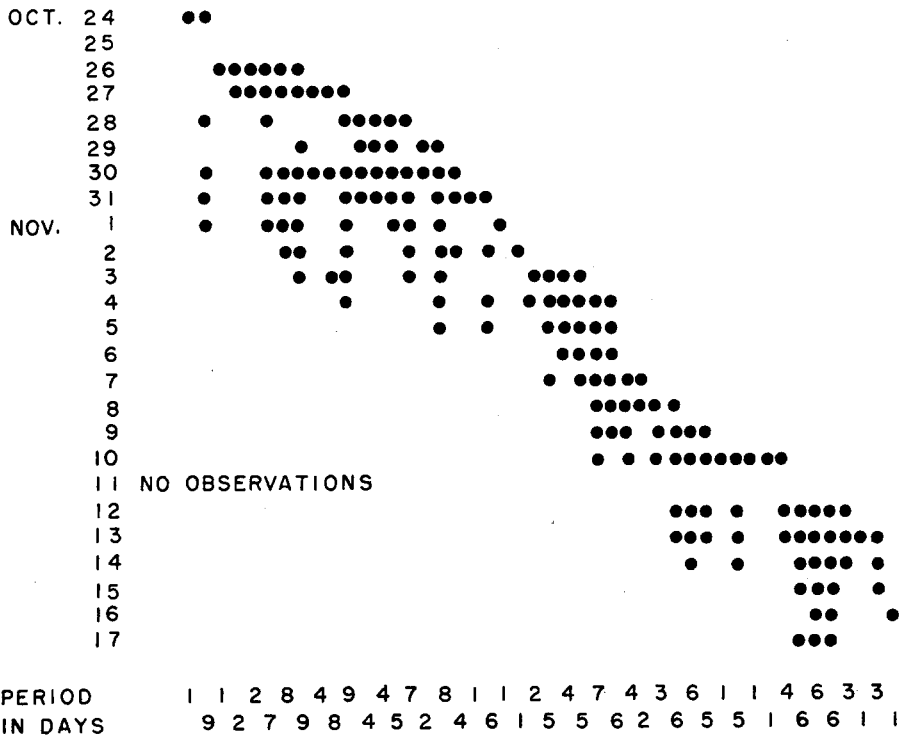


Fig. 2. Attendance at feeding station of 46 transient juncos. Horizontal lines give number of transients seen on each date. Vertical lines give records for individual birds. Bottom lines record numbers of days between first and last appearances of each transient.

already know each other (as witness the controlled approaches and avoidances of other juncos in accord with relations of dominance) and are already familiar with the environment.

On January 22 the feeding station was again invaded by an unusually large percentage of unmarked birds, which persisted for three days. On January 25 eight birds were trapped, suggesting the usual pattern. When observations were resumed in February, six of these birds were still visiting the station and mixing with the other birds. Two disappeared soon after, and the remaining four, which vanished between March 6 and 16, had nearly unbroken records of attendance. This invasion seemed to duplicate experience with the dairy flock and thus suggests the moving in of still a third flock.

Evidence of a process of familiarization.—Three sets of facts suggest that the early birds, upon their arrival, underwent a process of routinization, or of familiarizing themselves with the environment. Two such facts have already been mentioned. First, the juncos first seen watched but did not enter the station for eight days. Second, of the group of seven birds first marked, four were not seen for several days immediately thereafter but became steady visitors on November 2 or 3; one bird was never absent and one was absent only one day. Third, the remaining bird of this group, GR, was especially interesting, since its behavior made it possible to observe the steps by which it apparently became used to the station and its feeding arrangements. Food was spread both on the ground and on a bench. GR's behavior as recorded in the notes was as follows:

October 28: trapped.

November 1, 2, and 8: seen once briefly; no visits on intervening days.

November 15: made two visits; scratched under brush; did not approach food.

November 16: made 13 visits; at first visits scratched under brush, visits lasting several minutes, emerged twice momentarily; during last visits came out in the open occasionally.

November 17: made 13 visits; stayed in the brush but came frequently into the open; finally ate on the ground with other birds.

November 18, 19, 20, 21: ate on the ground but restricted its movements more than other birds.

November 22 and 23: continued to eat on the ground; often perched high in brush and seemed to watch birds on bench.

November 24: began to eat on bench.

One bird from the middle group (table 1) also showed similar hesitancy, tending to stay in the brush for two days. The writer has observed behavior similar to GR's in Slate-colored Juncos (Sabine, 1949), and something that appears to be analogous has been reported for hens introduced into new quarters (Douglass, 1948). Howard and Emlen (1942) and other observers have reported cases in which unfamiliar surroundings seem to influence behavior.

An objection might be entered against giving so much weight to the exceptional behavior of one individual. It has been the writer's experience in observing juncos that individually distinctive behavior is an exaggeration of a trait common to the species.

The transients.—Of the birds marked (table 1), 46 were transients. In view of the season, it seems probable that a large proportion of these were migrants, but some transients may have been winter residents that were members of other flocks.

In the length of their stay, as seen at the station, the transients varied from one to nine days (fig. 2, bottom lines). The earlier part of the period included birds that stayed seven, eight, or nine days. Those which stayed five or six were largely captured later. Birds present from one to four days were scattered throughout. The number of marked transients seen on any one day varied from 2 on the first day (October 27) to 14 on October 30 to 2 on the last day (November 17).

In six instances, two or three transients disappeared on the same day. This suggested the conjecture that these birds might belong to integrated migratory groups and so might be visiting the station together. An examination of their visiting records, however, did not support this. There was no special tendency to joint visits by these groups; joint visits occurred oftenest merely between birds that were most frequently seen. Table 3 shows the joint visits of all birds, resident and transient, on November 14. On that day, for example, BS, YA and TD, which all disappeared on November 18, made records as follows: TD made four visits, one with YA and two with BS, but two also with RS and YJ, which were both winter residents. The same sort of relationship held between BS and YA, and between each of these and two winter residents; there were

three joint visits between the transients, and three or four between them and winter residents. The record for November 14 is typical; the result would be the same if joint visits on any other day were examined.

The behavior of the transients differed from that of the residents in one respect: they visited the station oftener. This may be presumed to mean that they consumed more food than the residents. Table 5 compares the visits of 20 transients with the aver-

Table 5
Comparison between Frequency of Visits by 20 Transients and Mean Frequency of Visits by Winter Residents

Individual transients	Period of observation	Number of visits by each transient	Average number of visits by residents per bird	Number of residents
BA	Oct. 30–Nov. 1	10	4.5	6
RY	Oct. 30–Nov. 1	9	4.5	6
BC	Oct. 30–Nov. 1	12	4.5	6
GW	Oct. 30–Nov. 2	13	5.2	6
AR	Oct. 30–Nov. 3	23	7.2	6
LA	Oct. 30–Nov. 3	32	7.2	6
WN	Oct. 30–Nov. 4	28	12.2	6
YO	Oct. 30–Nov. 5	22	18.3	6
TB	Nov. 3–Nov. 7	20	16.5	6
ZR	Nov. 4–Nov. 7	25	17.6	6
BP	Nov. 4–Nov. 9	58	32.3	6
GT	Nov. 4–Nov. 10	74	37.0	6
WD	Nov. 8–Nov. 10	29	18.0	7
SC	Nov. 9–Nov. 13	42	23.5	9
SO	Nov. 10–Nov. 13	7	16.0	9
PN	Nov. 9–Nov. 14	20	27.0	9
CD	Nov. 12–Nov. 14	24	13.2	12
BS	Nov. 12–Nov. 15	34	21.0	12
YA	Nov. 12–Nov. 17	62	34.0	12
TD	Nov. 12–Nov. 17	50	34.0	12

age number of visits by the winter residents present during the same period. The 20 transients include all the birds that had visited the station on three or more days after records became available.

In two instances (SO and PN) the visits of the transients were fewer than the mean visits of the residents; in eighteen instances the transients made a larger number of visits. The percentage of excess varied, from YO with 20 per cent more than the average of the winter residents to LA with 340 per cent. Nine transients exceeded by less than 100 per cent, five by more than 100 per cent, and two by 100 per cent. These variations reflect considerable differences between individual transients. Some of them also ate for unusually long periods, a factor not taken into account in the number of visits. Typically the junco eats longest when solitary. It ceases to be restless, sits back on its heels, eats without moving, and may continue so up to twenty minutes. The transients made twelve solitary visits as against five by the winter residents, though the latter were more numerous. YA made five such visits. On one day, for example, GT visited the station 23 times in 7½ hours and ate for periods of six, ten, twelve, and eighteen minutes, ignoring the coming and going of other birds. Normally only a solitary junco eats for periods of such length.

The two lower graphs in figure 1 contrast the feeding performance of all the winter residents with that of all the transients by means of the daily average interval between

their visits. Except on November 12, when their average was affected by the small number of visits by PN and SO (table 5), the transients visited at substantially shorter intervals. Their feeding, however, was apparently not modified by changes of temperature. Unlike the case of the winter residents, no significant correlation is demonstrable between the variation in their average intervals and the changes of the three temperature readings (fig. 1, upper graphs). The small number of transients may possibly be responsible.

This distinctive aspect of behavior among transients, and its possible independence of temperature changes, probably reflects the need for a presumed deposition of fat associated with migration. Odum and Perkinson (1951), in a study of the White-throated Sparrow, have shown that such a deposition of fat is a prerequisite for migration, and they suggest that during long migrations these lipid deposits may be used up and may need to be replenished. Their study concerned the spring migration. The feeding behavior of the junco transients suggests that this species stops to replenish its migratory fat during the fall migration.

There is some evidence that the migrating birds that paused in their flight did not forage at random but attached themselves to a winter-resident flock. The vertical lines in figure 2 show that there was a difference in the proportion of absences between the transients marked between October 24 and 31 and those marked between November 1 and 16, as follows:

	Total number marked	Number appearing 1 day or 2 consecutive days	Number appearing with no absences	Number appearing with absences
Oct. 24-31	20	4	6	10
Nov. 1-16	26	9	15	2

The early transients, like the early winter residents, had spasmodic records with many absences. The later transients, a different set of birds no more familiar with the environment than the earlier transients, were nevertheless consistent daily visitors. In this respect they were like the late-arriving winter residents referred to earlier. It seems reasonable to suppose that they were consistent visitors for the same reason, namely, that they attached themselves to a group already routinized. The attachment thus inferred from the records of absenteeism is supported by the direct observations on five occasions at dawn (November 2, 8, 10, 12, 16), when large groups of unmarked birds were seen foraging outside the station along with the marked birds inside. A mechanism effecting such an association would distribute the transients among the wintering population and should therefore limit the number of them appearing at any one feeding spot. The number of visits by unmarked birds (table 2, col. 7) and the computed number of unmarked birds based on it (col. 8) fulfills this expectation.

THE FLOCK AT SEATTLE

The composition of the flock.—The feeding station at Seattle was set up on December 21, 1949. Juncos were in the neighborhood and at once started to visit in groups ranging up to 19 individuals. Trapping was begun on December 28. Table 6 shows that 32 birds were captured. They are divided into the classes which subsequent events showed probably to be correct. At first, however, no distinctions could be made between the birds in columns 2, 3, and 4. They seemed to be a feeding station flock of 26 birds. The six casual visitors were identifiable by the infrequency of their visits (col. 5) as at Deep Springs.

Snow began to fall on the second trapping day (December 29) at noon, and for the following five weeks fresh precipitation and low temperatures maintained a substantial

ground cover of snow. On February 4 and 5 a rapid thaw set in. These two dates were marked by the complete disappearance of the six casual visitors and the seven birds "from other flocks" in table 6. Ten days later one of the latter was seen twice, and 14 days later another was seen four times, after which they were not seen at the station again. During the preceding five weeks they had not been rated as casual visitors because the frequency of their visits seemed to place them within the flock. From these striking simultaneous disappearances it may be conjectured that these seven birds were only apparent members of the flock but really belonged to a third category, namely birds from other flocks which were nevertheless frequently present and had been brought to the station by the snow. The station was outside their usual foraging circuit and they detached themselves from the station when the difficult foraging period ended.

Song Sparrows (*Melospiza melodia*) were displaying analogous behavior at the same time. Of this species, 13 were marked, the first proving in the spring to be the resident male holding the breeding territory around the station. Like the juncos, these birds made frequent visits to the station during the period of snow, despite their intense intolerance of one another. With the exception of the "owner" and one other male, which was later observed to be a contender for the territory, the Song Sparrows also vanished with the thawing of the snow.

The departure of 13 juncos left 19 birds as the station flock (table 6, cols. 2 and 3), probably a mixture of residents and winter residents. These two groups became distinguishable at the time of the spring migration.

The integration of the flock.—A census was kept from January 5 to 26. It showed the same types of irregularity in timing, grouping, and individual visiting that had prevailed at Deep Springs and are illustrated in table 3. In one respect, however, the Seattle flock differed from that at Deep Springs. Presumably because of its smaller size, it sometimes moved as a unit, all the birds appearing together.

A daily roll also was kept in Seattle throughout the observations. Absences were most numerous at first but declined to zero after February 20. Of the 10 absences noted below during the period of dispersal, six were those of a single bird.

	Number of days	Number of birds	Number of absences	Percentage of absences
Jan. 5-11	7	18	45	.36
Jan. 12-24	13	19	30	.12
Jan. 25-Feb. 4	10*	19	17	.09
Feb. 5-20
Feb. 21-25	5	19	0	.00
Feb. 26-Apr. 3	37	decreasing	10	

* No observations on February 2.

A conjecture might be made that absences were more numerous at first because, when a new feeding spot is included in a circuit already routinized, the birds may require time to become familiar with it. Some light was thrown on this point when a new baited area was started on February 22. Few birds went to it at first, but its use increased markedly as time went on.

During the interval without recorded absences shown above, there was an almost complete lapse in visits at the station. Eight observations made at dawn during this period showed from 6 to 16 birds. On several of these days, not a single junco was seen at a later hour. The weather was still, dull, and humid, with occasional rains, mists, and fogs. Undoubtedly these conditions limited foraging. A gleam of sunshine almost instantly brought large groups to the station.

The existence of a foraging circuit (referred to above as possibly already formed before the station was set up) could not be verified at Seattle; rather, it was assumed on the basis of the evidence gathered at Deep Springs. The prevalence of conifers and a maze of fenced yards was unfavorable to tracing the marked birds, and it was not possible to select one site for observation as more likely than another. There was, however, one feeding spot frequented by the birds that happened to be visible from the post of observation. It was a patch of lawn about 30 yards distant from the station. Flights from the station to this spot were not counted but they were numerous and were seen probably every day. A group at the station might move to it as a unit, or a part of the group might do so. As between this spot and the feeding station, the behavior of the birds was like that at Deep Springs, namely, foraging groups as a rule moved from one small area to another.

Table 6

Schedule of Marking and Tentative Classification of the Flock at Seattle

Date trapped	Residents	Winter residents	Residents from other flocks	Casual visitors
Dec. 28	OR, TM, P			
29	Q, OC, W, C	Y, R, GM	L	
30	LG	GP	PR	PY
Jan. 1	OW, WY, TW	OG	LC, CM, ML, TR	TY
2		YM	YR	CW
4		TC		
9				GY
12	CG			
14				MW, OP

Only one marked bird was lost from the Seattle flock. It was trapped on the first day (December 28). It is not listed in table 6 because its early disappearance after thirteen days of frequent visiting prevented its tentative classification. This low rate of loss probably reflects the absence of predators. None was seen at the station, and predatory birds were doubtless less numerous in the Seattle area than in the almost undisturbed wildness of the Deep Springs basin. It seems reasonable to regard the low rate of loss in Seattle as supporting the interpretation that the high losses at Deep Springs were due to predation rather than to inherent instability in the social structure of the flock.

At Deep Springs the presumption that the marked birds formed a stable group was somewhat clouded by the presence of unmarked birds. The conclusion that these were probably trap-shy members of the flock rested on a reasonably plausible network of observations and interpretations, but it could not be tested. In Seattle this element of uncertainty was reduced to a minimum. The 19 birds of the flock (table 6, cols. 2 and 3) were never accompanied by more than three unmarked birds. Of these one was very dark and was identifiable because it was number 4 in the pecking hierarchy. One was unusually small and pale-colored. The third was medium in coloration of the hood. These features could be readily seen in a good light and when the bird was quiet. Two unmarked birds alike in coloration were never observed together at any time when such comparisons were possible, and such opportunities were fairly frequent. Special attempts to trap these unmarked birds showed that they were observably trap-wary.

These facts tend to support the conclusion that the more numerous unmarked birds associated with the marked flock at Deep Springs were also trap-wary. The unchanging

membership of the Seattle flock supports the view that juncos in winter are integrated by some means which tends to segregate flocks from each other.

The dispersal of the flock.—The tentative classification of the winter flock into residents and winter residents, as shown in table 6, was suggested by differences of behavior when the flock dispersed in the spring. Seven birds (col. 3), like the winter residents at Deep Springs, visited the station daily and vanished abruptly. They were distinguished from the remaining 12 birds (col. 2) superficially by the fact that they disappeared earlier. At the station a sprinkling of unmarked birds noted on February 22 was the first sign that migration was underway and the presumed winter residents were last seen from February 25 to March 2. These early departures were interpreted as meaning that these seven birds were migratory, since they failed to display an attachment to the winter feeding area which was exhibited by the remaining 12.

The dispersal of the residents was associated with the retention of the area as breeding territory by the dominant bird of the winter pecking order. The order of dominance of the 12 residents was as follows: OR, TM, TW, W, OW, YW, CG, C, LG, P, Q, and OC. OR mated with LG. This fact was first noted on February 28 as probable. How much earlier the mating process had started is not known. It was not evidenced by any courtship gestures at any time, being shown by an increasing tendency for the two to arrive and depart together. This lack is a reminder of the probable incompleteness of observations collected at a single post. It seems likely that some courtship gestures occurred. The writer has seen them in a different pair of the species and also has seen elaborate displays in a migratory flock of *J. hyemalis* (Sabine, 1952).

Another fresh development, the appearance of new types of intolerant behavior on the part of OR, was first noted on February 17. These did not destroy the gregariousness of the flock. So long as the birds were visiting the station, they continued to do so in groups with the mated pair or either of them. Nor did the new behavior supersede normal winter intolerance. It was discriminatory and occasional, being evoked by certain birds, especially at first, and becoming a more general irritability of the mated pair toward the end of March.

In order to describe these special forms of intolerance, it is necessary to explain the normal winter intolerance which was a background for it. With the junco, intolerant behavior in winter, during the flocking phase, seems to be essentially a means whereby gregarious individuals become spaced as they eat or perch. The spacing is maintained with some sharpness. In order to study it the feeding station had been enlarged in February to 56 square feet (14×4). With abundant baiting evenly distributed, this area would accommodate 10 or 12 birds about two feet apart with only a small amount of pecking at first, and quiet feeding without pecking might continue for several minutes. With fewer birds there might be no pecking; that is, no evidence of intolerance might be evoked.

Against the background of this characteristic behavior, the new manifestations of intolerance by OR stood out as extraordinary. The first object of OR's special intolerance was TW. Instead of being ignored in the normal way with the spacing just mentioned, TW was attacked at sight by swoops from long distances, even the whole length of the station. Such attacks always permitted TW to keep ahead; the junco is a ritualistic antagonist. TW's response might be to leave at once, but more often TW resisted by remaining at the station and being chased around it, sometimes for several minutes. TW's resistance did not include an attempt to peck or chase OR but consisted only of a persistent refusal to depart. Either bird might break off such a chase by taking its departure, although TW would do so more frequently than OR. By March 13, OR had

extended his attacks to all the birds except C, Q, and OC; C and OC had been subjected to intolerant pecking and chasing by OR's mate, LG.

The common element in all variations of OR's behavior was the indication that winter spacing for eating was now too close. OR no longer ignored birds eighteen inches or two feet away. In this behavior the birds of higher rank were selected for special intolerance (perhaps the males), but it was nevertheless spasmodic. OR lapsed into normal winter tolerance at times and ate with the flock. About March 27 he became generally irritable with all birds (except his mate) at all times, including unmarked birds that had invaded the area. But he was especially irritable toward TM, second in the pecking order, which with OC, the omega bird, had lingered longest at the station.

LG also became intolerant, chased the birds below her in rank, and before the dispersal was completed showed that she had become dominant over 5 of the 7 birds superior to her in the line of dominance. It seems reasonable to suppose that she became dominant to all, although contacts between her and the other 2 birds were not observed. What was seen at the feeding station was not necessarily a complete record of her behavior.

The three birds that ranked immediately below OR in the pecking order also developed sporadic but strong intolerant behavior of the same type. It was first noticed in the case of TW on February 23, of TM on February 27, and of W on February 28. If this order was not merely an accident of observation and if TW really was the first bird below OR to develop what may be called territorial behavior, it might account for the fact that TW was the first bird toward which OR showed strong discriminatory intolerance. TM, TW and W also showed by their reactions to fellow juncos that they were in a phase similar to that of OR. There was no reason to suppose that they had mated, and it might therefore be inferred that OR had probably developed territorial intolerance before mating. The relation of these birds to each other and to the lower-ranked birds of the flock did not disturb the pecking order as it had prevailed during the winter, except of course in the case of LG.

One practical effect of the expanded intolerance shown by OR was to prevent the other birds from eating. Although only one bird at a time had his attention, the others were disturbed and showed it by moving about and occasionally even by taking cover in a dense part of the brush. Instead of departing, they used the subordinate birds' most characteristic method of resistance, which is to remain, retreating to the brush and returning when the opportunity offers. By this method they were often able to eat after OR departed.

The departures of the 10 birds other than OR and LG took place singly between March 12 and April 3. The history of the dispersal suggests that there was an initial attachment to a familiar environment not only by OR and LG but by all the birds. The ultimate detachment was resisted for a considerable period. Starting not later than February 17, the periods of resistance of the 10 individuals ranged from nearly a month to forty-six days. It might be considered an even stronger sign of attachment that several birds, probably males, developed territorial behavior similar to that of OR. The intolerance of OR and LG probably had its place among the stimuli bringing about the conditions that led to the dispersal.

SUMMARY AND CONCLUSIONS

Observations of two winter flocks of free-living, color-marked Oregon Juncos (*Junco oreganus*), made at feeding stations in eastern California and Seattle, Washington, and during successive seasons, provided evidence for the following tentative conclusions:

1. Such flocks are integrated and stable in membership up to the time of dispersal in the spring, when migration or the establishment of breeding territory begins.

2. Integration into a stable flock is apparently effected by the restriction of individual birds to a common feeding circuit consisting of definite feeding spots. Within the circuit solitary individuals and groups of all sizes move freely. A relatively large flock rarely if ever moves as a unit but relatively small flocks may do so.

3. A process of familiarization takes place in the case of the earlier birds of a flock introduced into a new environment. Later birds do not experience this process, presumably because they attach themselves to birds already routinized.

4. It is possible for two neighboring flocks to amalgamate permanently. When this occurs, there is some evidence that the newcomers may abandon the feeding circuit they have formerly used and adopt that of the flock with which they amalgamate. There is no evidence of hostile intolerance on the part of the flock in possession of the feeding circuit.

5. The average daily visits of resident members of the flock, and hence presumably their food intake, show a demonstrably significant correlation with temperature. More frequent visits were made on cold days.

6. It is possible for visitors not members of the flock to utilize a feeding spot for several weeks when feeding is difficult by reason of heavy snow. Such visitors come as frequently as members and mix freely with the flock, but they detach themselves completely when normal feeding conditions are restored.

7. A winter flock may be composed wholly of winter residents or, in a region where the species breeds, may include both residents and winter residents.

8. Individual birds from other flocks make casual and infrequent visits at a feeding spot, together with the members of the flock in whose foraging circuit the spot falls. There is no display of intolerance toward such visitors.

9. Juncos show individual differences in trap-wariness, some never entering traps.

10. Transients that pause in their migration may feed more frequently than winter residents. They probably attach themselves to flocks already established and do not forage at random.

11. The dispersal of a flock of winter residents at the beginning of the migratory season takes place in a series of abrupt disappearances. The dispersal of a flock of resident birds may be effected by the emergence and intensification of a special form of intolerance, not characteristic of winter behavior, on the part of a dominant male and his mate. Resident birds offer a passive resistance to this aggressive intolerance, which interferes with foraging, before they disappear. The effect of this special intolerance is to expand the narrow spacing tolerated in the close social relations of the winter flock into the wide spacing characteristic of the breeding phase of the species.

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