PREMIGRATORY BEHAVIOR AND ORIENTATION IN BLUE-WINGED TEAL (*ANAS DISCORS*)

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NUMEROUS investigations have been made on avian behavior during migration. Almost all sight, sound, and radar observations of migrating birds show good correlations with weather conditions (Hochbaum, 1955; Lack, 1963). Orientation studies of caged birds during migration indicate that birds utilize celestial cues (Kramer, 1952; Sauer, 1961; Hamilton, 1962) as do directions taken by released birds (Matthews, 1961; Bellrose, 1963) and homing experiments (Matthews, 1955; Kramer, 1957). Recordings of caged birds show premigratory nightly unrest and indicate a bird's physiological readiness to migrate. Although these studies enhance our understanding of avian behavior during migration, information is scarce on the bird's activities on the breeding grounds prior to and during periods of migration.

The objectives of this study were 1) to ascertain if any behavioral changes took place prior to as well as during migration, 2) to determine if these were associated with specific weather patterns, and 3) to see if all birds under observation reacted at the same time and in a similar manner to the same environmental conditions. The investigation included more than 340 hours of observations of birds in the field, of wild birds placed in orientation cages, and of a group of hand-reared birds in a large flight pen.

The study was conducted with Blue-winged Teal (*Anas discors*) during the summer of 1963 and 1964 on the Delta Marsh, a large waterfowl breeding area at the southern tip of Lake Manitoba in Manitoba, Canada.

METHODS

Observations were made in the marsh and at the upper end of Portage Creek, a large stream extending about 5 kilometers south of the marsh. All birds at a particular location were counted every 10, 15, or 30 minutes and the number exhibiting different behavior patterns noted. The data were averaged for half-hour periods and then placed on a percentage basis. When comparing early and late activity during the season, 13 August was taken arbitrarily as the separation date. For certain comparisions the day was divided into three different periods: (1) 0400 to 0900, (2) 0930 to 1500, and (3) 1530 to 2100 hours. Light readings were taken with a Weston light meter calibrated with a Weston illuminometer to show values in foot candles.

The behavior of a group of hand-reared birds, composed of 21 adults and 13 juveniles kept in a large flight pen with reed sides open only to the sky, was recorded in a similar manner as that of the wild birds.

Recordings were also made of birds in three orientation cages placed in the marsh during the late summer of 1964 (Figure 1). Around each cage was placed a thick 5-foot burlap blind that blocked the view of external objects without casting a

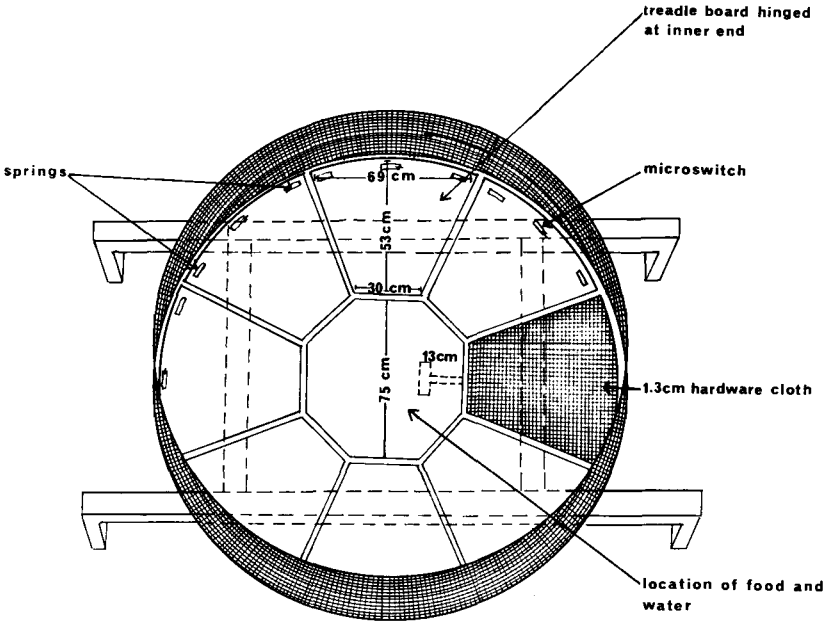

Figure 1. Orientation cage.

shadow in the cage. Three wild adult males that had migrated at least once and had completed the postnuptial molt were placed in each of two cages and three juvenile males in the third. Small slits in the burlap permitted an observer lying on the ground to watch the birds.

Weather data were recorded every 4 hours, and Canadian Air Force weather maps provided additional information on general weather patterns and frontal movements. An average temperature change of 4°C from the previous day's recording period was used in comparisons of temperature with activity. Wind direction was blocked into three groups: W to NNE, NE to SE, and SSE to WSW. Wind speed groupings of 0 to 8, 9 to 16, and above 16 km/hr were used. Barometric pressures greater than 758 mm were arbitrarily considered high, and the amount of cloud cover was separated into three categories: 0 to 0.3, 0.4 to 0.6, and 0.7 to 1.0. A probability level of 0.05 was required for significance.

RESULTS AND DISCUSSION

General activity.—The wild Blue-winged Teal arrived at Portage Creek from the marsh in the morning about 1 hour before sunrise when it was too dark to see the dial on the light meter. This is considerably earlier than the beginning of morning activity of Wood Ducks, *Aix sponsa* (Hein and Haugen, 1966). The arrival period lasted from 10 to 15 minutes, after which all birds fed heavily. Sporadic flight activity lasted for about 45 minutes after arrival. During the first half hour of feeding many

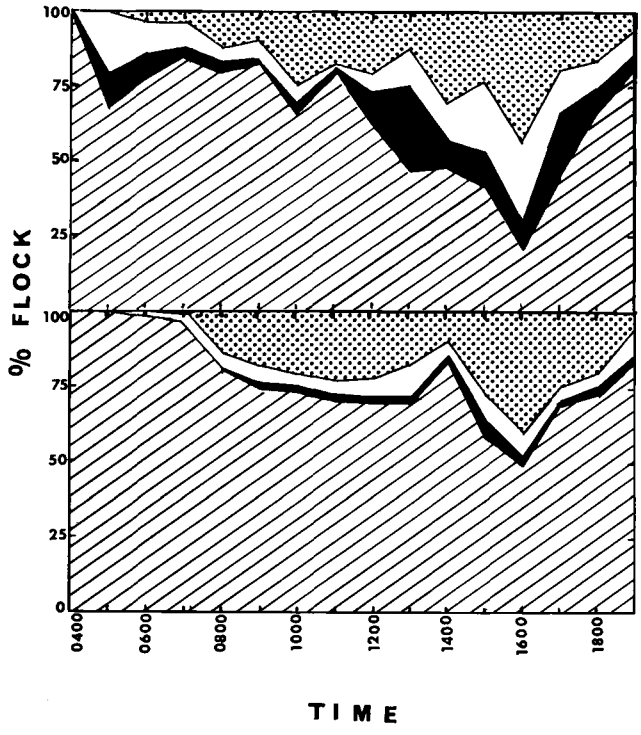

Figure 2. Comparison of daily behavior of wild teal during early summer (upper) and late summer (lower). Diagonally hatched, feeding; black, swimming; unmarked, comfort movements; stippled, resting.

female calls were heard but only a few male calls. Within an hour after arrival calling by both sexes dropped considerably.

Intensive feeding lasted approximately 3 hours, after which about 25 per cent of the birds started resting (Figure 2). Resting was always preceded by comfort activities (McKinney, 1965). Throughout most of the day interchange between feeding and resting ducks was continuous, but the percentage performing each activity remained rather constant. At about 1500 hours the number of feeding birds decreased to approximately 55 per cent. The mud flats along the creek were favorite resting sites. Rarely were the teal more than 2 or 3 feet from the water's edge. The number of wing-flaps was high (0.08 per bird per half hour) during the first half hour after arrival but then dropped, occurring mainly when the birds were disturbed. Dashing-and-diving (McKinney, 1965) was sporadic; it generally occurred when a few birds were engaged in rigorous bathing.

By 1730 hours the number of teal feeding increased again to about 70 per cent. As departure time approached the number of resting birds de-

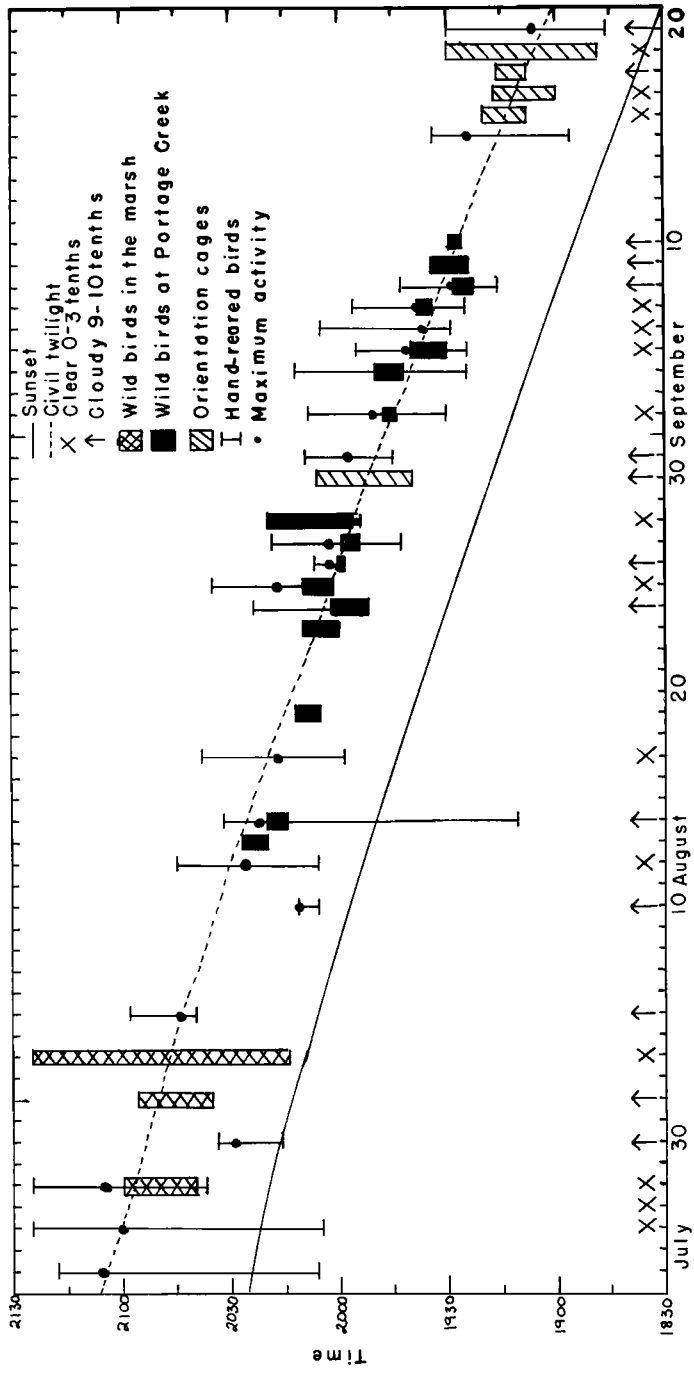

Figure 3. Relationship between sunset, civil twilight, and maximum flight activity exhibited by the birds in the marsh, hand-reared birds, and birds in the orientation cages.

creased rapidly and the feeding birds began to form loose groups with some attendant comfort activity. Calling increased steadily and reached a maximum about one half hour before departure.

Between sunset and civil twilight at light intensities generally between 4 and 2 ft-c, the teal stopped feeding and swam rapidly or flew to form compact groups near the center of the creek. The birds in a group often started swimming up or down the creek, with some birds feeding, others bathing, dashing-and-diving, and wing-flapping. Often the lead birds were the only ones alert. A few minutes before leaving the birds stopped feeding and swimming and milled around rather aimlessly, a few continuing to bathe, stretch, and wing-flap. Ten seconds prior to flying most birds became alert and then took off.

Flock size usually varied between 10 and 80 birds. In groups of more than 100 birds definite subgroups could be distinguished. A subgroup of about 20 birds in the center of a large group often began to show heightened bathing activity, dashing-and-diving, and wing-flapping, then became alert and flew off leaving the remainder of the birds milling about. Then other portions of the group behaved similarly in turn until all had left. Flight time was always near twilight at light intensities of about 0.2 ft-c.

Miskimen (1955) describes similar preflight activities for three other duck species, but swimming maneuvers began at light intensities between 600 and 100 ft-c and all birds left between 10 and 0 ft-c.

Compared with the wild teal, feeding by the hand-reared birds was more sporadic and in larger groups. Evening preflight activity resembled that of the wild birds, and although it started earlier, the time of maximum activity corresponded closely to the departure time of the wild birds (Figure 3). The alert birds initiating this activity were often adults, implying perhaps that the few alert birds of a maneuvering flock in the wild are also adults and the leaders of the flocks.

Observations made throughout the night with an infrared spotting scope showed that the hand-reared teal spent the entire night on the water in a very compact group. Raccoons (*Procyon lotor*) and weasels (*Mustela* spp.) frequent the shores of the marsh at night and ducks resting there as they do during the day would probably be easy prey.

Variations in activity associated with weather.—Cloud cover had a significant effect on evening flight times only at the 0.1 level. With a light drizzling rain the number of teal engaging in comfort movements and feeding increased. McKinney (1965) also noted an increase of comfort movements with rain. The birds commonly flew about a great deal during and after moderate to heavy rain. Bathing, dashing-and-diving, and wing-flapping increased when the rain stopped. Thunder had no effect, but with hail most birds moved into the reeds for protection. During

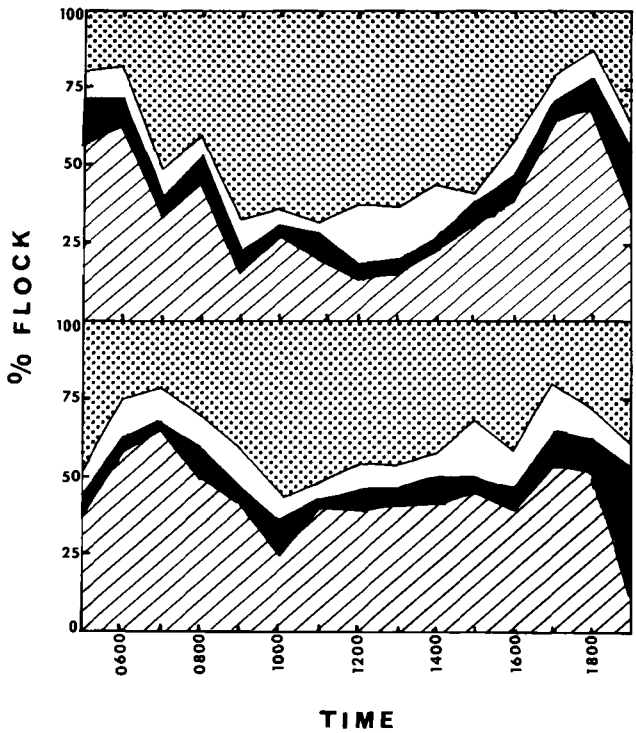

Figure 4. Comparison of daily behavior of hand-reared teal during clear (upper) and cloudy (lower) weather. Symbols as in Figure 2.

cloudy weather the percentage of hand-reared birds feeding during the day was significantly higher (Figure 4).

In the orientation cages it was difficult to determine any consistent correlations between activity and weather except that cloud cover had a significant depressing effect in four out of six cases. The blind around the cages probably prevented the birds from experiencing the true wind direction and speed.

Seasonal change in daytime activity.—Early observations on the percentages of wild teal feeding, swimming, or performing other activities were made in the marsh, those later in the season at Portage Creek.

In late summer feeding increased while comfort movements decreased during the early part of the day (0400–0900) and swimming decreased throughout the entire day (Figure 2). This is probably related to the large number of flightless birds during the early summer and the buildup of fat reserves for migration.

There was little calling by any birds during early and mid-July, but

by the second week in August the high pitched nasal decrescendo of the female was heard frequently. The males also began calling more often during the early part of August. The amount of dashing-and-diving increased as the season progressed, especially in the juvenile birds. Wing-flapping increased as overall activity increased. Preflight behavior also became more intricate and prolonged, but the illumination associated with flights did not change significantly during August and September as Hein and Haugen (1966) noted with Wood Ducks.

During late summer birds move into staging areas at the southern end of the marsh. These include the southern portion of a few large bays, Portage Creek, and a group of sedimentation tanks used for sewage disposal by the town of Portage-la-Prairie. A flight census on 10 September showed that 95 per cent of all Blue-winged Teal in the marsh were confined to these areas.

According to Hochbaum (1955) the first birds to leave in migration are adult males. The largest percentage (30 to 40 per cent) of adult males was observed between 13 and 23 August; but as late as 7 September about 15 per cent of the teal were adult males. In all instances these birds tended to fly and feed together, although often accompanied by other birds. Whether adult birds lead the migrating flocks was impossible to tell. Hawkins (*in* Bellrose, 1958) found too few adult birds present at this time of year to act as leaders, but this may only reflect the fact that adult teal are trapped less readily. A cannon net used at the station in mid-September caught a large number of adults.

During the latter part of the summer the hand-reared birds showed increased feeding and swimming and decreased resting early in the morning (0400 to 0900) (Figure 5), thus acting in part like the wild birds. The number of birds flying and the number and length of flights increased with the season. This is partly a function of the number of birds capable of flying, but also an indication of unrest.

The birds in the orientation cages reached a peak in flying, calling, and in total daily activity between 9 and 13 September.

Daily activity on migration days.—A significantly higher percentage of teal fed during midday (0930 to 1500) on days of departure. Also preflight activity occurred earlier than usual and feeding dropped off even sooner. This period of nonfeeding probably allows time for partial digestion of food and emptying of the alimentary canal. As these birds usually make short flights at the start of migration (Bennett, 1938; Lincoln, 1950), some extra weight carried as undigested food should not be detrimental. Some increased wing-flapping was manifest on departure days, as on 10 September when almost all the birds left my observation area.

As early as 1915 hours on this date 35 teal were forming a group and

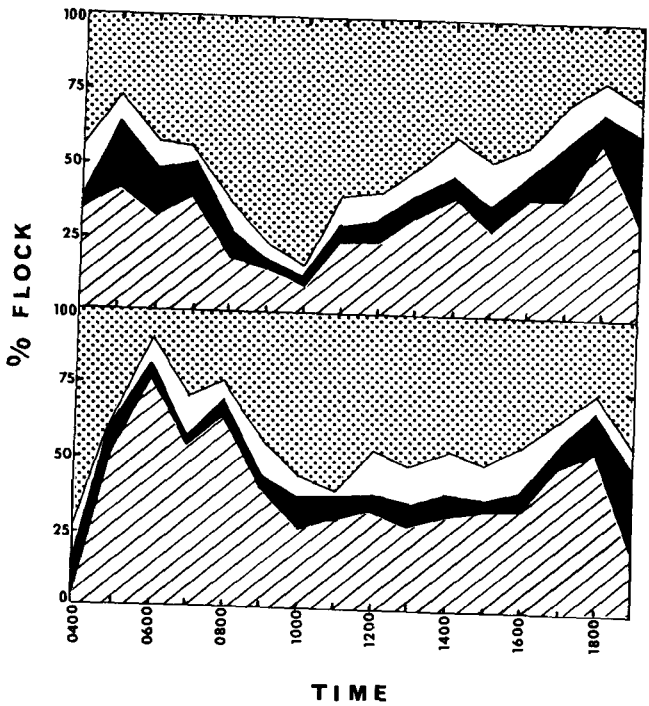

Figure 5. Comparison of daily behavior of hand-reared teal during early summer (upper) and late summer (lower). Symbols as in Figure 2.

slowly swimming south at a light intensity of 150 ft-c as compared to the usual 4 to 2 ft-c. The birds moved about 200 feet and turned into the wind, some stretching and bathing, but most alternating between feeding and resting on the water while maintaining their position. In the space of 30 minutes this group exhibited this behavior three times with fewer birds feeding each time. Meanwhile another large group of about 40 teal was forming to the north, and a small group of 19 birds fed to the south. By 1945 hours the northern group slowly swam south behaving exactly like the previous large group. They passed the feeding birds who paid no attention to them. All calls seemed to come from the feeding birds. At 2000 hours both large groups were separated by 100 yards, but behaved identically. The slow southerly swimming was periodically interrupted by turns into the wind with two or three birds constantly stretching, bathing, and wing-flapping. Singles and doubles continually swam or flew to join these groups. When the farthest group reached a bend in the creek about 200 yards to the south they stopped in the water and preened, then after 3 minutes they continued around the bend, closely followed by the second group. Both groups came close together with no

birds alert and none calling. Two other small groups also came around the bend. At 2029 hours all birds flew southeast, leaving the creek bed and rising to 70 feet before going out of view.

On other migration days a similar pattern was noted although not as vividly. Birds grouped earlier than on nonmigration days, swam slowly to the south, and apparently called only while feeding. They performed numerous comfort movements and only a few lead birds were alert at any time, except just before takeoff when almost all became alert. Flock size was always less than 50 birds.

Miskimen (1955) suggests that the preflight swimming maneuvers may serve the function of building up flock organization. I believe this is true. The grouping, swimming, comfort movements, and orientation noted all probably function in this way. Miskimen also suggests that weather and social stimuli are both involved in the fall migration of ducks, and that cloudy and windy prefrontal weather is important in allowing birds to maneuver, fly, and probably feed together for a few days. With clearing weather the birds leave in these same groups.

The teal formed recognizable groups only in the evening, but slight differences were apparent in the behavior of the different groups on the same evening, even when the birds flew back into the marsh. These differences involved the time of grouping, time of flying, amount and direction of swimming, amount of comfort activities, and amount of calling. Possibly these differences express the physiological state of the birds in the group, which might be joined by birds in a smilar physiological state. The few birds that remained alert through most of the activity probably were the most highly motivated and perhaps the leaders of the flock.

The early and more intricate preflight maneuvers on migration days may aid in mutual stimulation and establishing better flock organization for the long flight ahead. Other observations of preflight activity of waterfowl on migration days also showed some group behavior (Brackbill, 1952; Lennerstedt, 1958; Mendall, 1958). Many other birds, especially among passerines, do not migrate in well organized flocks, and whether such group behavior occurs in these species is questionable; observational data are sparse on this point.

In contrast to the wild birds, the hand-reared birds exhibited decreased feeding and increased resting on departure days. Comfort movements and swimming remained the same, although on 10 September an unusual amount of swimming indicated that the birds were restless this day. These unexpected findings may result from the fact that the caged birds probably do not attain the same physiological readiness for migration as early as the wild birds. This is substantiated by observations of delayed migration of hand-reared birds (Weller and Ward, 1959; Dane, pers. comm.).

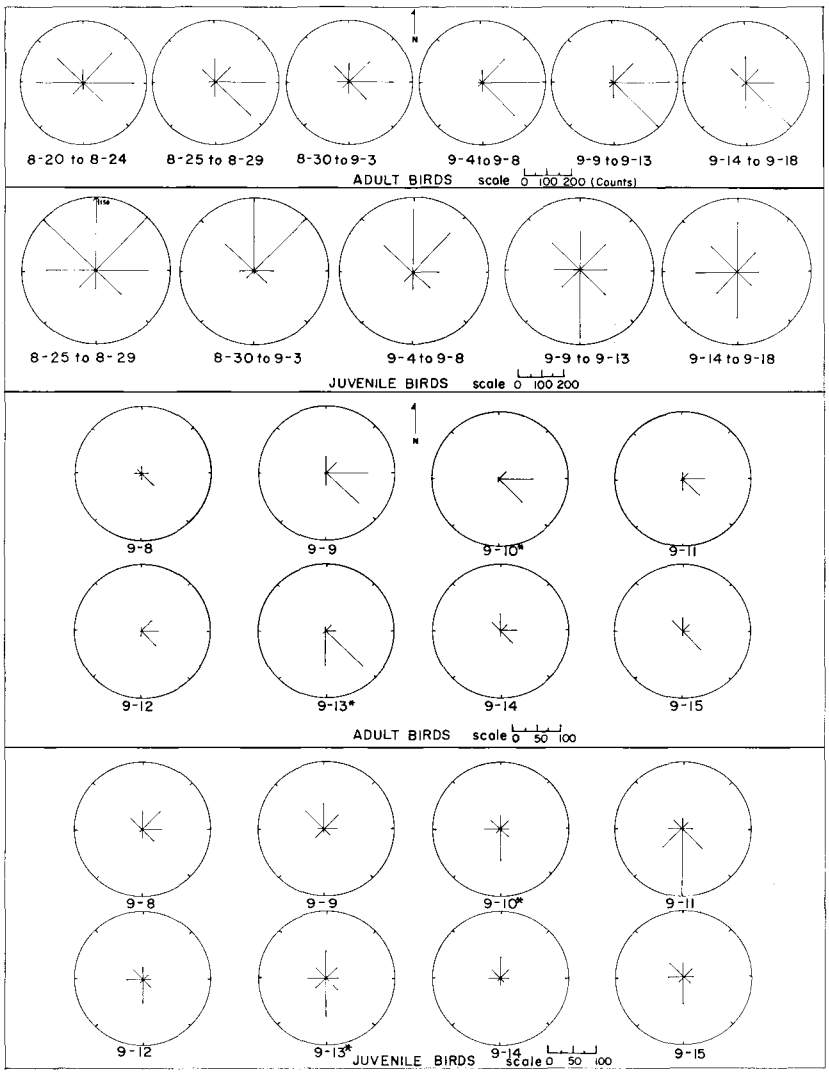

Figure 6. Change in orientation during the entire migration period (top two figures) and daily change during the last major departure of wild birds (lower figures); * denotes a migration day.

Orientation.—The only truly oriented behavior seen in the field was the swimming in the direction of flight during preflight maneuvers. The birds did not always swim up or down the creek, but if they did they invariably flew in the direction they were swimming. The greatest amount of directed swimming observed was on 10 September when most of the

TABLE 1

COMPARISONS OF ACTIVITY PEAKS WITH WEATHER CONDITIONS PRECEDING AND DURING KNOWN DATES OF MIGRATION

	Orientation cages	Wild birds	
Number of observations	39	6[1]	8[2]
Number of days after cold front	1.44	0.92	1.31
Number of days after known migration date	0.83	—	—
Number of days after wind shift North	0.79	0.34	0.35
Number of days after rising barometer	0.91	0.19	0.18
Number of days since 4°C drop in temperature	2.08	1.75	2.67
Per cent observations occurring with barometer above 75.88 mm	42.10	83.33	87.50
Per cent observations with barometer			
rising	34.21	66.67	62.50
falling	28.95	33.33	37.50
steady	36.84	00.00	00.00
Per cent observations with cloud cover			
0 to 0.3	76.92	66.67	50.00
0.4 to 0.6	5.13	16.67	25.00
0.7 to 1.0	17.95	16.67	25.00
Per cent observations with wind speed			
0 to 8 km/hr	64.10	50.00	62.50
9 to 16	25.64	33.33	25.00
16	10.26	16.67	12.50
Per cent observations with wind direction			
W, NW, N	58.97	100.00	100.00
NE, SW	17.95	0.00	0.00
E, SE, S	23.08	0.00	0.00

[1] Migration dates when all birds under observation appeared to leave.

[2] Includes also 2 days when only half the birds apparently left.

birds migrated. Possibly the movement of birds into staging areas on the south side of the marsh also was oriented behavior.

No directional behavior was noted among the hand-reared birds. Although southerly flights in the pen increased, the percentage of these remained quite low. Their lack of activity and orientation is probably related to their later departure than the wild birds. Bellrose (1958) observed oriented behavior in captive wild teal at sunset in late fall.

During 46 days of recording the direction of maximum activity varied between orientation cages (Figure 6). Activity of adult males in one cage was principally to the east at first, and switched to the southeast after 25 days. The juvenile birds showed a continued preference for the north except from 10 to 13 September when the peak activity shifted to the south. The southerly-directed activity corresponded closely with actual

TABLE 2

WEATHER CONDITIONS AT DELTA DURING THE KNOWN TIMES OF MIGRATION

Date	Time	Cloud cover (tenths)	Wind speed (km/hr)	Wind dir.	Bar. press. (mm)	Bar. rise-fall steady	Temp. °C	4°C change
15 Aug	1530	2	1	NNW	757.3	R	22	Rise
	1930	0	0	NW×W	758.2	S	20	–
	2330	0	0	NW×W	758.2	S	16	–
	0330	2	1	NW×W	758.2	S	13	–
24 Aug	1530	9	9	NW×W	758.0	F	14	–
	1930	10	15	NW	757.0	F	13	–
	2330	10	12	N	756.5	F	11	–
	0330	10	12	W	755.0	S	11	Rise
27 Aug	1530	6	2	NNW	749.2	R	21	–
	1930	7	4	NNW	748.0	S	18	–
	2330	8	6	NNW	748.0	S	15	–
	0330	10	9	N	748.0	S	14	–
4 Sep	1530	3	9	NW	757.8	R	16	Fall
	1930	9	0	NNW	758.2	R	13	Fall
	2330	0	3	SW	758.2	S	10	Fall
	0330	0	3	SW	758.0	S	4	Fall
7 Sep[1]	1530	1	1	N	762.5	R	13	–
	1930	5	0	NNW	762.5	S	10	–
	2330	3	0	SW×W	762.8	R	6	–
	0330	2	1	NE	763.5	R	5	–
8 Sep[1]	1530	1	3	N	762.1	F	15	–
	1930	10	2	N	760.0	F	13	–
	2330	10	0	N	758.0	F	12	Rise
	0330	10	2	E	755.0	F	12	Rise
10 Sep	1530	10	11	NNW	764.0	R	6	Fall
	1930	10	16	NW	767.5	R	6	Fall
	2330	0	7	SW×W	770.3	S	3	Fall
	0330	1	3	SW×W	770.8	R	–3	Fall
13 Sep	1530	1	9	N	758.0	R	11	Fall
	1930	3	17	N	762.5	R	6	Fall
	2330	10	17	N	764.5	R	4	–
	0330	4	1	N	764.5	R	1	Fall
	0730	1	1	N	768.2	S	2	Fall

[1] Half of the birds being watched appeared to go.

migration days. One group of adult males exhibited no apparent directional choice throughout the migratory period.

Several examples of oriented behavior were noted in the cages. The adult birds in cage two continually sat facing out in the southeast portion of the cage. During periods of activity they walked back and forth between the center and this side. During the period of southerly-oriented

activity the juvenile birds walked to the south, pecked at the wire sides, returned to the center to take some food and water and then walked south again in rapid sequence. More than 50 per cent of the flights I saw were in a southerly direction. A bird often walked to the north side of the cage, faced easterly to southerly, and generally made several flight intention movements before flying over the center of the cage to the other side. The birds often circled around before alighting.

No correlation was evident between peak activity and orientation. Mewaldt et al. (1964) suggest that nightly unrest and directional choice may be separate components of a bird's behavioral apparatus. They found in sparrows of the genus *Zonotrichia* that restlessness occurred before orientation and that high unrest was not necessarily orientated. My results suggest that orientation may be a better indication than unrest of actual time of departure.

Weather and migration.—Table 1 shows the relationship between known migration days and the passage of cold fronts and related phenomena; Table 2 gives the exact weather conditions during the departure period. Migration appeared to occur on the same day or the day following a cold front except on 4, 7, and 8 September when the wind shifted northerly without the passage of a front. Generally if the front passed through early in the day the birds left that evening. Almost all well documented migration dates were associated with similar weather conditions.

Conditions such as these where birds take advantage of favorable winds resulting from the relative position of large continental air masses have been termed "pressure-pattern flying" (Landsberg, 1948; Lowery, 1951). Hochbaum (1955) was able to relate almost all major fall movements of Blue-winged Teal, Canvas-backs (*Aythya valisineria*), Redheads (*Aythya americana*), and Mallards (*Anas platyrhynchos*) to such an arrangement of pressure masses. Other investigators have shown correlations between migration and meteorological factors associated with the above conditions (Lincoln, 1935; Bennett, 1952; Dillon, 1957; Sieh, 1958; Bourne and Patterson, 1962; Lack, 1963).

A number of workers have tried to determine whether any single weather parameter is a key factor for initiating movement. Bellrose (1951) suggested that a cold front was important in starting the migration of waterfowl that had remained in the north late into the fall. He later (Bellrose, 1957; Bellrose and Sieh, 1960) showed that cold temperature has this effect whether associated with a cold front or not. Conceivably other changes in the weather picture could initiate the movement once cold temperatures had made it mandatory for the birds to leave. Hochbaum (pers. comm.) noted that when falling temperatures were associated with a front the birds at Delta did not leave until the weather cleared, even

though migrating birds from the north could be seen through breaks in the clouds. Probably the birds from the north had outflown the conditions that initiated their flight.

Hassler et al. (1963) and Brooks (1965) both show good correlations between departure of birds and a wind shift into the north. My data for 4, 7, and 8 September indicate that a wind shift creating favorable winds for migration is at least part of the stimulus for departure.

Those birds reacting to a wind shift toward the north, falling temperatures, rising barometer, cloudy or rainy weather followed by clearing, and a drop in relative humidity all occurring at once as on 10 September, would be the ones most assured of favorable conditions for migration. Birds reacting to single cues, for example a wind shift alone, as the teal did on 7 and 8 September, or a rise in barometric pressure, or a drop in temperature, will have the least chance of survival. Flocks of birds in a premigratory state are probably made up of individuals at different motivational levels that react differently to the same weather conditions (Drury and Keith, 1962). The behavior of the maneuvering groups prior to evening flight, such as described in this paper, tends to synchronize their behavior and develop a more homogeneous group for migrating.

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SUMMARY

Observations were made of Blue-winged Teal in the field, in a large flight pen, and in orientation cages to determine the relationships between behavior, weather, and migration.

Birds under all three conditions exhibited similar early morning and evening behavior, but during the middle of the day the birds in the field spent a considerably longer time feeding. Times of peak flight activity for all birds in the evening were closely associated with a light intensity of 0.2 ft-c. Both the hand-reared birds and the birds in the field showed similar preflight swimming behavior.

Comfort movements and general activity increased with rain and the hand-reared birds showed increased activity during days with heavy cloud

cover. Cloud cover had a depressing effect on the activity of birds in the orientation cages.

Birds in the field and hand-reared birds showed increased feeding during the latter part of the summer.

On migration days, in contrast to nonmigration days, wild birds fed more during the daytime but ceased feeding earlier in the evening, began extended preflight maneuvers earlier than usual, exhibited less calling but more comfort movements, and became especially alert only a few seconds prior to departure.

The occurrence of directed swimming movements before flying was the only true orientation observed in the field. Hand-reared birds showed neither increased activity nor orientation on migration days. This is probably associated with their slower change in physiological states.

The direction of maximum activity varied considerably, but in two of the three cages activity increased in the southeast and south portions of the cage as the migration season progressed. Maximum oriented behavior occurred between 10 and 13 September when the last major departure of wild birds took place in the marsh.

Almost all migration was associated with the passage of a cold front. Of all related meteorological factors involved, favorable winds were apparently the most important.

In this study caged birds did not aid greatly in understanding the wild birds' behavior. In most cases the reverse was true, but in a few instances the behavior of the hand-reared birds indicated interesting points that were not obvious in the field, such as the possible organizers and leaders of the flocks and the nocturnal behavior of the birds.

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