METEOROLOGICAL AND SOCIAL FACTORS IN AUTUMNAL MIGRATION OF DUCKS

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A study entitled "The role of weather in bird migration," a joint project of the Department of Zoology and Entomology and the Department of Physics and Astronomy of The Ohio State University, began in the summer of 1950 and continues to the present time. The work is supported by funds from the Ohio State University Research Foundation to aid fundamental research. The project was initiated by Dr. A. N. Dingle in cooperation with Dr. L. S. Putnam, Dr. D. J. Borror, Dr. C. A. Dambach, and Dr. E. H. Dustman. I wish to thank all members of the committee for the help they have given me. My special thanks are due to Dr. Putnam, who has been closely associated with me in every aspect of the work.

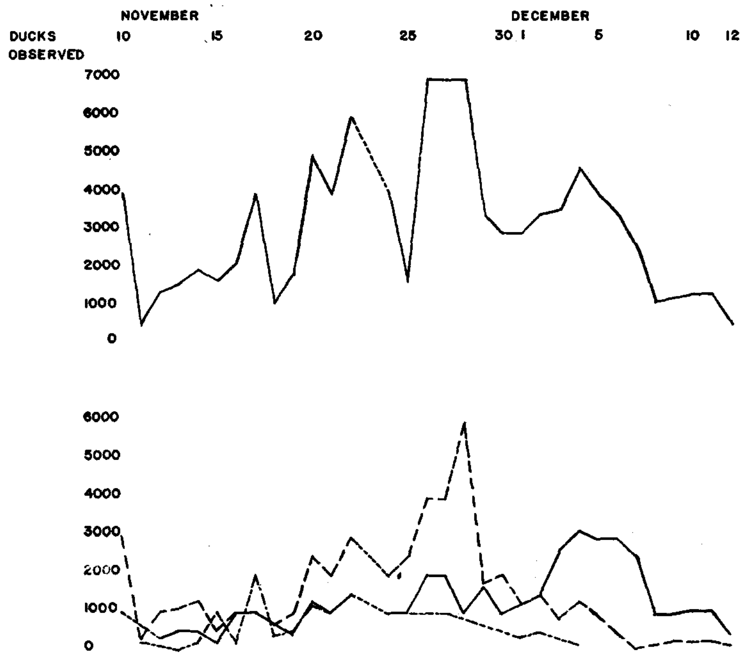

Fig. 1*a* (above). Total daily counts of ducks at O'Shaughnessy Reservoir, near Columbus, Ohio, in November and December, 1951; broken line indicates gap in the record.

Fig. 1*b* (below). Numbers of Mallards (continuous line), Black Ducks (heavy dashes), and Lesser Scaup (dot-dash); again, the evenly broken line of short dashes indicates gaps in the record.

Observations of migrating ducks were made daily at O'Shaughnessy Reservoir, 17 miles north of Columbus, Ohio, from October 24 to December 12, 1951, with one interruption on November 23. The reservoir, which is one-third of a mile across at its widest point and seven miles long, is surrounded by agricultural land and scattered dwellings. Hunting on the reservoir is prohibited. My car was used as a blind; except when moved, it did not disturb the ducks.

Black Ducks, *Anas rubripes*, Mallards, *A. platyrhynchos*, and Lesser Scaups, *Aythya affinis*, were present in numbers sufficient to warrant special study. At night one could hear ducks arrive and leave at intervals. Just after sunrise each morning large flocks came, drank, and swam about for a time, then rested on shores or in rafts for the remainder of the day. They departed between sunset and dark. All flock movements observed were shortly before or after sunrise or sunset, never during the day. Regular counts were made each afternoon when ducks on shore joined the rafts prior to evening departure. Due to difficulty in making accurate counts of moving ducks, numbers were recorded to the nearest hundred. In cases of more than a thousand ducks in a single raft, a fraction of the group was counted and an estimate made of the whole. Total daily

Table 1

The Relationship of Meterological Events to Behavior of Ducks at Columbus, Ohio

Date	Air Temperature, °F	Amount of overcast	Clouds[1]	Wind force (Beaufort units) and direction	Direction of flight of ducks
Nov. 10	60	½	C	2 SW[2]	....
11	33	¼	As	1 N	....
12	55	total	Sn	2 SE	....
13	63	total	Sn	2 S	sw
14	59	¼	C	4 SE[2]	....
15	58	1/10	As	1 SW	....
16	37	¼	C	2 N	....
17	30	¼	C	4 NW[2]	....
18	26	¾	Sn	4 W[2]	n
19	27	¾	C	3 N[2]	....
20	31	½	As	0	n,s[3]
21	45	½	As	4 S[2]	n,w,s
22	45	total	Sn	2 S[2]	n,w,s
23	42	total	Sn	3 S	....
24	34	½	C	2 N	s[3]
25	32	total	Sn	4 S	s
26	34	total	....	4 NW[2]	....
27	33	½	C	0	s,n[3]
28	41	½	S	3 SW	s[3]
29	49	9/10	As	2 S	s,se,n[3]
30	30	½	As	2 S	s,ne[3]
Dec. 1	49	....	....	2 S	e
2	51	¾	S	2 S	s,se[3]
3	59	¾	S	2 S	e
4	54	....	....	2 W	e
5	46	total	S	1 E	e,se
6	61	....	....	3 S	s,e,nw
7	....	total	Sn	2 SE	s[3]
8	43	total	Sn	0	n
9	36	total	S	4 W[2]	n
10	35	¼	C	2 SW	n
11	35	total	Sn	3 SE	n
12	25	¾	As	3 W	....[3]

[1] C, cumulus; S, stratus or stratocumulus; Sn, stratonimbus; As, altostratus.
[2] Ducks oriented facing the wind.
[3] Crescent flight observed.

counts are recorded in figure 1*a*, and counts by species in figure 1*b*. Weather conditions and some aspects of behavior recorded at each observation are shown in table 1.

In the case of migrating spring passerines, Bagg *et al.* (1950), Lowery (1951), and Dennis (1954) all have found numbers varying with weather changes. Rowan (1929) observed that fall migration movements of ducks increased in clear, cold weather with high barometric pressure. I have attempted to find consistency between weather variations and major migratory movements of ducks in the fall and also the relationship between weather elements and behavioral changes which may lead to migrating movements.

Records made each day of the form of flock and direction of flight (table 1) show that after circling and gaining altitude flocks flew out of sight in various directions. On certain days after gaining altitude the ducks formed long, attenuated, crescent-shaped flocks and flew south or a little southwest until out of sight. When in crescent flight they never flew in any direction other than toward the south. This behavior was noted on November 20, 24, 27, 28, 29, 30, December 2, 7 and 12 (table 1). Comparisoh of these dates with figure 1*b* shows that every such date was followed by a day on which one or more species decreased in number. Population decreases were recorded on 17 days. Evening departure was observed prior to 11 of these days, and on 9 of the 11 days crescent flight pattern occurred. While the record is not complete there appears to be an association between this form of flight and birds leaving the study area. Crescent flight pattern does not function in migration only, nor are migratory movements accomplished by its means alone; further study might prove worthwhile. There appears also to be association between crescent flight pattern and clear weather. The data in table 1 show that this behavior was observed only on evenings which were clear or partly clear, never on a day of complete overcast.

METEROLOGICAL FACTORS IN MOVEMENT

Clear sky.—The graph in figure 1*a* shows sharp decreases in total numbers of ducks on November 11, 18, 25 and 29. Since no movements of flocks into or out of the study area were observed during the day, the declines recorded indicate that many birds resting there the previous days left during the nights and did not return. The weather record in table 1 shows that on the day previous to each of these dates the sky was clear, or at least partly clear, in the evening. No great declines in numbers were observed following overcast days. But there were many clear days during autumn migration, and not all of them were associated with appreciable changes in duck population. According to data shown in figure 1*b*, population fluctuations in different species were not always in the same direction; one species might increase and another decrease. Factors other than weather must therefore be involved.

Light intensity.—There was marked change in behavior of rafted ducks in late afternoon when stragglers and ducks from shores and sand bars joined the rafts. About that time the ducks began an activity that I call swimming maneuver. Parties of a dozen or more ducks began to swim together, back and forth among the other ducks. After 10 or 15 minutes they stopped and mingled with the others. Soon other parties began the maneuver and shortly most of the raft consisted of maneuvering parties of ducks, sometimes several hundred together but usually 25 to 50 in a group. After a period of swimming maneuvers the ducks began to fly away in flocks. Each departure flight started from an area in the raft where a maneuver had recently ended. After each large flight the remaining ducks usually consolidated the raft and performed additional maneuvers before others flew. This was repeated until all had flown. When a flock left a large raft it was impossible to know if the same ducks which maneuvered also flew, and if, therefore, mutual stimulation played any part, but usually the last 25 or 50 ducks maneuvered as a group and then flew away together. In these cases the relation between group swimming maneuver and group flight was evident, as the same individuals participated in both activities.

I recorded the time and light intensity when swimming maneuvers began, when the first flock flew, and when all were out of the reservoir. Light readings were made with an ordinary photographic light meter which registered in foot-candles. For the sake of uniformity readings were made with the glass exposed to the sky at zenith. With a few exceptions in each case (see figure 2) swimming maneuvers began when light intensity was between 100 and 600 f.c., first flight occurred between 10 and 200 f.c., and all were

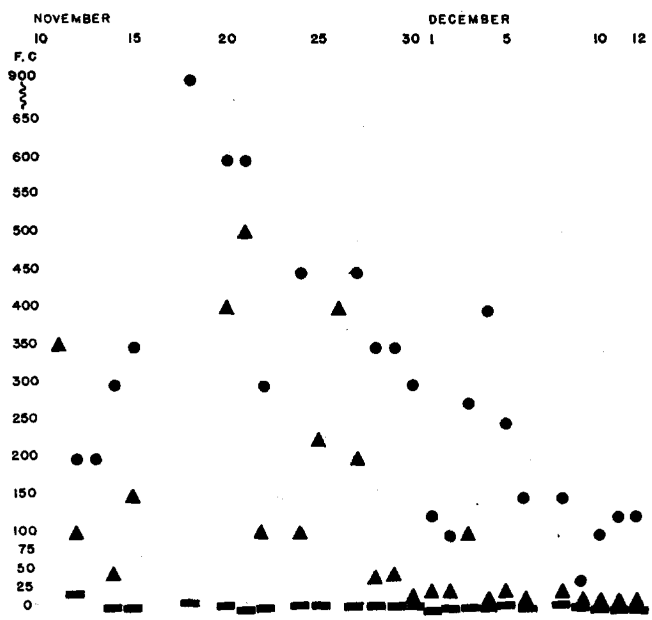

Fig. 2. Comparative light intensities for times of beginning of swimming maneuvers (dots), times of first flights (triangles), and times by which all ducks had left (bars).

gone when light was from 0 to 10 f.c. These light ranges are rather wide; if records had been kept by species the ranges would have been much narrower. Even so, there was greater consistency with light intensity than with the hour at which the various activities took place. This finding of course does not eliminate the possibility that the position of the sun may influence this behavior.

Overcast sky.—According to my field notes, cloudy days (see table 1) were marked by increased group activity among all ducks. This was particularly noticeable among scaups, which were sometimes active nearly all day. There was less sleeping in rafts, less loafing on shores and sand bars, more group activity, more moving about the reservoir by short flights and small swimming rafts. Total activity, while less intense than during evening pre-flight periods, was noticeably greater on cloudy days than on clear days. No accurate measure of over-all activity was devised.

Wind.—Wind speed and direction had no observable influence upon the direction in which ducks left the study area each evening. In rising from the water all faced the wind until they gained altitude, then they flew away in various directions, as shown in table 1. Wind force affected behavior of individual resting ducks by causing each to face into the wind when the wind velocity was 3 Beaufort units or higher (table 1). At such times ducks crowded close together in rafts or in parties along shores. Preening, feeding and other activities were at a minimum. Oriented groups dispersed temporarily when individuals engaged in some activity; they broke up when evening swimming maneuvers began. The effect of orientation in groups on subsequent group behavior could not be accurately measured at the time, but I think it increased the intensity of flocking reactions, as will be shown below.

INTERACTION OF WEATHER AND SOCIAL FACTORS IN MIGRATION

Behavior, in a bird or any other animal, theoretically results from stimuli acting through the sense organs and nervous system on muscles and glands. Behavior resulting from any stimulus or combination of stimuli depends in part upon the bird's hormonal balance, state of nutrition, and other physiological variables. It also depends in part upon preceding stimuli, including social stimuli. This was evident in the case of observed evening maneuvers. Without exception ducks left the reservoir in flocks after following the set behavior sequence outlined. The fact that they never left singly or at random times supports the theory of effective social stimulation in this activity. Increasingly gregarious behavior leading to evening flight accompanied decreasing light intensity. Fall migration in ducks also probably depends partly upon interacting weather and social stimuli. Population decreases were most evident during clear weather, usually following periods of cloudiness or wind. This suggests that the movements may have been facilitated by social stimulation during typical pre-frontal weather and the change to clear weather. During cloudy days the ducks clung together in rafts more closely and were more active than they would have been in clear weather; if there was some wind they spent many hours with their bodies oriented in the same direction. If the pre-frontal period was prolonged they maneuvered together several times in evening pre-flight activities, flew together and probably fed together. Thus through mutual stimulation and synchronized behavior, flock organization built up. When clearing weather brought conditions favorable for flight into territory beyond the previous feeding range, this organization became effective in migration. Crescent flight pattern may be one evidence of such flock organization. While all migratory movement does not follow this weather sequence, I think much of it does. This theory would explain in part why large migration movements often follow cold-front passage, especially if pre-frontal stormy weather lasted for an extended period and was followed by a strong cold front and rapidly clearing sky.

The time of day at which the front passes and the sky clears may be important but has not been investigated. Air and water temperature and occurrence of precipitation were recorded at each observation. If they affected behavior the results could not be determined under existing conditions. Possible behavioral changes induced by these variables should be studied in the laboratory.

If weather were the only variable influencing migration, then according to this theory every cold front would be marked by complete turn-over in duck population at any one observation point. This does not happen because of other interacting stimuli; these include nutritional (Wolfson, 1954*a*, *b*), physiological (Rowan, 1931), and social factors.

SUMMARY

Study of migrant Black Ducks (*Anas rubripes*), Mallards (*A. platyrhynchos*) and Lesser Scaups (*Aythya affinis*) near Columbus, Ohio, showed that the daily cycle of resting and feeding was regulated by light intensity; resting ducks became increasingly active as light decreased in the evening. There was more activity among ducks on dark, overcast days than on bright days. Strong winds induced compact rafting of ducks; all faced the wind. Decreases in population number were recorded following evenings of clear sky and were often associated with flight in crescent-shaped flocks. A theory is proposed holding that during typical pre-frontal weather ducks may build up flock organization in response to decreased light, strong winds and possibly other weather factors; when clearing weather follows, mutual stimulation in organized flocks facilitates movement from the area. The rate and time of migratory movements may thus be strongly influenced.

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