EFFECT OF WEATHER ON AUTUMN SHOREBIRD MIGRATION IN EAST-CENTRAL ILLINOIS[1]

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The effect of weather on migration has been under study since the late 1800's, but even yet there is considerable disagreement among workers on this subject.

Cooke (1885*a*, *b*) was apparently the first to associate migration and weather, correlating spring movements with high temperature, low pressure, and, due to the low pressure, southerly winds and overcast. He surmised that conditions were reversed in autumn. Von Haartman and Bergman (1943) were able to correlate migration in Europe with pressure systems and cold fronts in autumn, but were not able to correlate increased intensity of southward migration and cold weather per se. Thomson (1953) and Mascher (1955) did not consider pressure important. Mascher (in Sweden) also considered changes in humidity, wind conditions, and atmospheric electricity in connection with passing fronts as unimportant, but thought that temperature was of greatest importance. Stolt (1959) in Scandinavia noticed "a close connection between falling temperature and intensified migratory movements." He found no correlation with variations in pressure, humidity, wind direction, and cloudiness. Svärdson (1953) stated that for "early migrants, e.g. waders, experience at Ottenby shows anticyclonic weather to be the worst 'bird weather' when the number of passing and resting birds is at its minimum. Later in the season anticyclonic weather more often gives numerous birds." Trowbridge (1902) thought it probable that many birds use the wind as a physical agent in migration. Lack (1960) supposed that "while migration is more common with following than opposed winds, this is normally due to other associated weather factors." Later (1962, 1963) he reversed his opinion and considered wind direction important. Hassler et al. (1963) attributed importance in the Midwest in autumn to a clockwise wind shift from south to north as a stimulus to migration. Although this is usually associated with the passage of a cold front, they felt that the wind shift was the primary factor. The occurrence of autumn migration with cold fronts has been pointed out by many workers, among them Bennett (1952) in the Midwest. Hinde (1951) suggests an interaction between internal factors of the bird (its physiological state) and weather factors in such a way that the influence of each weather factor probably varies with each of the others and with the state of the internal factors. Perhaps the apparent lack of agreement

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among different workers concerning the effect of weather on migration can be explained in part by what Hinde has suggested, and in part by the fact that birds in different regions may react differently.

The present study reports on work conducted from 10 September to 5 November 1960 and 1 July to 5 November 1961 at a small shallow pond approximately ¼ mile north of Champaign, Illinois. This pond was apparently a concentration point for shorebirds, since it was one of few in the area which contained sufficient available food and feeding space for these birds. The 20 species which were recorded during the two migrations are: Semipalmated Plover (*Charadrius semipalmatus*), Killdeer (*Charadrius vociferus*), American Golden Plover (*Pluvialis dominica*), Black-bellied Plover (*Squatarola squatarola*), Common Snipe (*Capella gallinago*), Spotted Sandpiper (*Actitis macularia*). Solitary Sandpiper (*Tringa solitaria*), Greater Yellowlegs (*Totanus melanoleucus*), Lesser Yellowlegs (*Totanus flavipes*), Pectoral Sandpiper (*Erolia melanotos*), Baird's Sandpiper (*Erolia bairdii*), Least Sandpiper (*Erolia minutilla*), Dunlin (*Erolia alpina*), Short-billed Dowitcher (*Limnodromus griseus*), Stilt Sandpiper (*Micropalama himantopus*), Semipalmated Sandpiper (*Ereunetes pusillus*), Western Sandpiper (*Ereunetes mauri*), Buff-breasted Sandpiper (*Tryngites subruficollis*), Sanderling (*Crocethia alba*), Wilson's Phalarope (*Steganopus tricolor*).

METHODS

Observational data were obtained by recording species and numbers of shorebirds seen on irregularly spaced trips usually made once a week, and during the height of migration, several times a week. Observations were usually made at about 0700 hours CST, but often trips were made later in the day, and sometimes morning and afternoon trips were made on the same day.

Weather data were obtained from Chanute Air Force Base, Rantoul, Illinois, about 15 miles north of Champaign, and from the Illinois State Water Survey in Champaign. The five weather conditions considered most important and most readily comparable with migration in this study are: the passage of cold fronts, a clockwise wind shift toward north, the occurrence of precipitation, and falling daily maximum and minimum temperatures.

Periods between observations (2.3 day average, 5 days absolute maximum used in the calculations) were given a + or – rating for each weather condition, depending upon whether the condition occurred or not. Numbers of individuals moving into or out of the pond were totaled separately for + and – periods, and the chi-square test was applied. For each weather condition the mean number of birds migrating for + and – periods was computed. The two means were then summed and the percentage for the mean of the + period

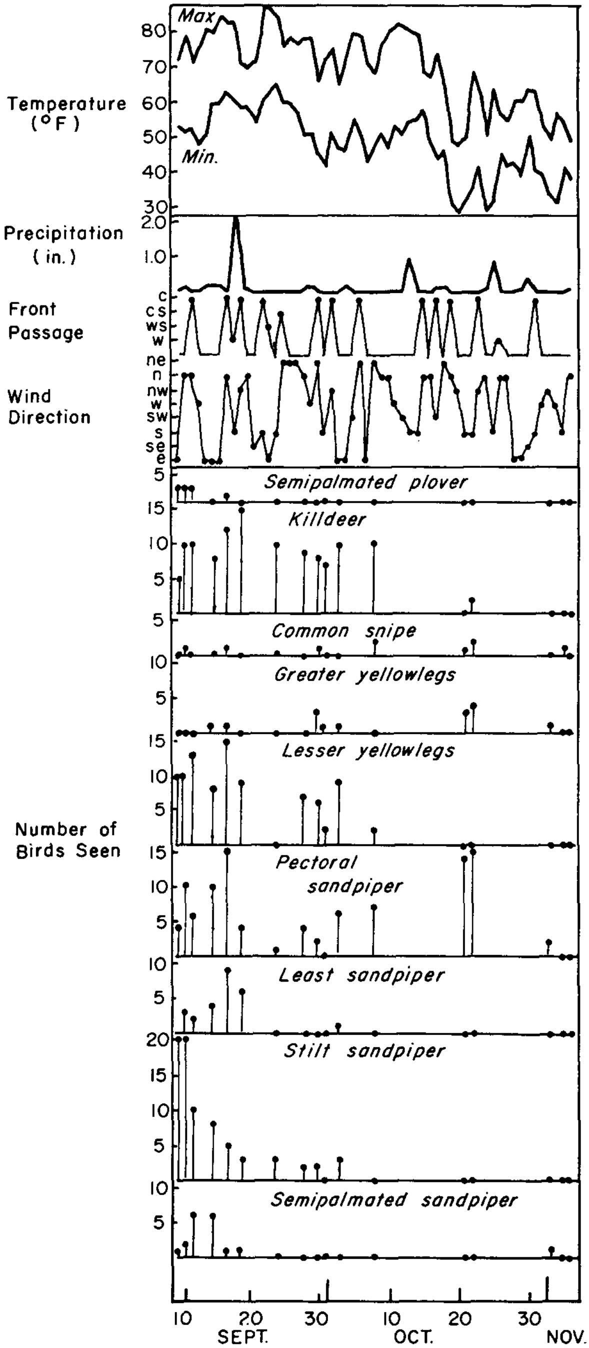
TABLE 1
FALL MIGRATION DATA, 1960, 1961

Species	Arrival	Departure	Peak date(s)	Peak No.
		1960		
Semipalmated Plover	–	17 Sept.	–	–
Killdeer	–	22 Oct.	19 Sept.	15
Golden Plover	8 Oct.	8 Oct.	8 Oct.	1
Black-bellied Plover	19 Sept.	8 Oct.	19 Sept., 8 Oct.	2
Common Snipe	–	4 Nov.	8, 22 Oct.	2
Greater Yellowlegs	–	2 Nov.	22 Oct.	4
Lesser Yellowlegs	–	8 Oct.	–	–
Pectoral Sandpiper	–	2 Nov.	–	–
Least Sandpiper	–	3 Oct.	–	–
Dunlin	2 Nov.	2 Nov.	2 Nov.	5
Stilt Sandpiper	–	3 Oct.	10, 11 Sept.	20
Semipalmated Sandpiper	–	2 Nov.	–	–
Buff-breasted Sandpiper	–	10 Sept.	10 Sept.	2
		1961		
Semipalmated Plover	24 Aug.	13 Sept.	31 Aug.	8
Killdeer	9 July	4 Nov.	17–19 Sept.	20
Golden Plover	8 Oct.	8 Oct.	8 Oct.	2
Black-bellied Plover	24 Aug.	31 Aug.	31 Aug.	2
Common Snipe	5 Sept.	29 Oct.	14 Oct.	8
Spotted Sandpiper	9 July	7 Sept.	9–16 July	5
Solitary Sandpiper	3 Aug.	17 Sept.	17 Aug.	6
Greater Yellowlegs	3 Aug.	4 Nov.	24 Oct.	13
Lesser Yellowlegs	16 June	14 Oct.	7 Sept.	125
Pectoral Sandpiper	10 July	14 Oct.	3 Sept.	50
Baird's Sandpiper	17 Aug.	19 Sept.	3 Sept.	3
Least Sandpiper	9 July	13 Sept.	3 Sept.	35
Dunlin	24 Oct.	29 Oct.	24 Oct.	8
Short-billed Dowitcher	16 July	13 Sept.	3 Sept.	4
Stilt Sandpiper	8 Aug.	19 Sept.	13 Sept.	20
Semipalmated Sandpiper	8 Aug.	17 Sept.	5 Sept.	21
Western Sandpiper	3 Sept.	13 Sept.	13 Sept.	3
Sanderling	24 Aug.	5 Sept.	31 Aug.	6
Wilson's Phalarope	12 July	5 Sept.	12 July 5 Sept.	2

was determined. This value is used as the per cent correlation of migration with the weather conditions in Figure 3.

RESULTS AND DISCUSSION

All species apparently reacted in a similar manner to weather conditions, and therefore are discussed collectively below. An idea of the number of birds


Temperature (°F)
Max
Min.
80
70
60
50
40
30
Precipitation (in.)
2.0
1.0
Front Passage
c
cs
ws
w
Wind Direction
ne
n
nw
w
sw
s
se
e
Number of Birds Seen
Semipalmated plover
Killdeer
Common snipe
Greater yellowlegs
Lesser yellowlegs
Pectoral sandpiper
Least sandpiper
Stilt sandpiper
Semipalmated sandpiper
10 20 30 10 20 30
SEPT. OCT. NOV.

involved can be ascertained from Table 1. Figures 1 and 2 show the observational data obtained for the more common species, with weather data added for comparison. The correlations shown in Fig. 3 are derived from data for all species. Fifty per cent correlation indicates that half of the birds moved when the designated weather condition was present, and half moved when it was not present, hence there is no significant correlation with that condition. A correlation value significantly ($p \leqslant 0.02$) below 50% indicates that migration was inhibited or at least not favored by that condition. A value significantly above 50% indicates that migration was favored and, in fact, was initiated when movement out of the area occurred.

The correlations with the movements out are considered the most accurate, since the starting point of the birds and the weather conditions at that time are both known, whereas they are not known for movement in. Therefore, the discussion below concerns only movements out.

In general, migration was positively correlated more highly with wind shifts toward north, cold fronts, and precipitation than with the other two conditions (Fig. 3). In every period of time where comparisons were made, correlations with wind were greater than with cold fronts or precipitation, although not always significantly greater. Correlation with cold fronts and precipitation was essentially equal.

Precipitation was positively correlated with migration at all times except during the first half of migration in 1961, when there was no correlation (Fig. 3*e*). The effect on migration, however, was probably indirect. Since the pond had no outlet, rain caused the water level to rise, and with a small rise in water level a disproportionately large area of the gently sloping pond edge was covered. Feeding areas and food availability were both reduced and the birds left the area. During the warmer months the water level did not rise as much as it did later in the season, with a comparable amount of precipitation because of higher evaporation and because the dryer soil took up more water. The data support an indirect effect of precipitation on migration here, since there was no correlation during the first half of migration (warmer months) in 1961 when rain caused very little rise in water level.

Positive correlation with falling maximum temperature never occurred. Negative correlation occurred in the last half of 1961 (Fig. 3*e*, *f*), and in 1960–61 combined (Fig. 3*c*), but in all other instances there was no significant correlation in either direction. These data suggest that in some cases migra-

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FIG. 1. Autumn migration of the more common shorebirds, 1960, and weather conditions. Front designations: c, cold front; cs, stationary cold front; ws, stationary warm front; w, warm front.

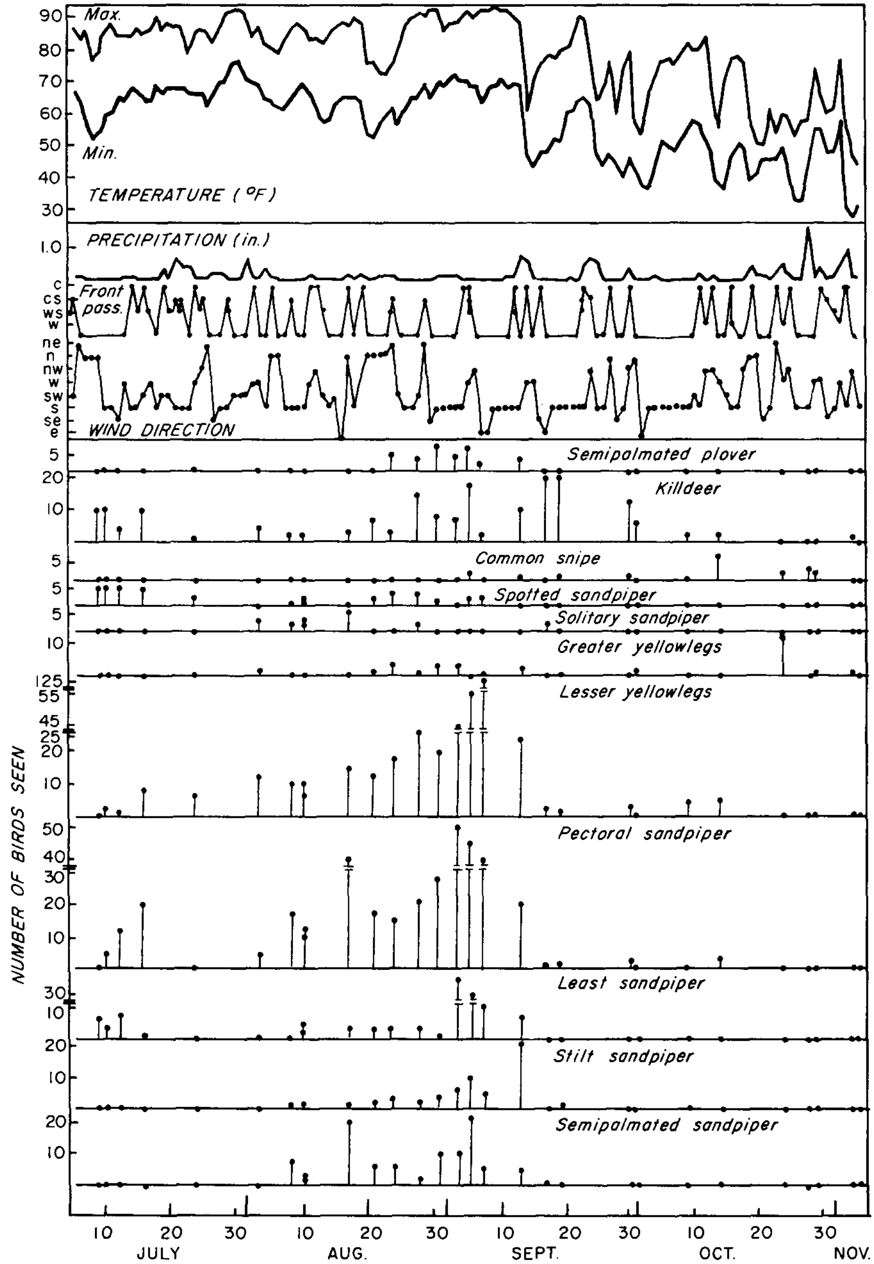

FIG. 2. Autumn migration of the more common shorebirds, 1961, and weather conditions.

tion is inhibited by a falling trend in daily maximum temperature, but the validity of this observation is questionable. Probably falling maximum temperature has no effect on migration.

Falling minimum temperature was not significantly correlated with migration in 1960, 1961 (Fig. 3*a*, *b*, *d*), or in the first half of migration in 1961. However, there was significant positive correlation in the last half in 1961. In general, temperature drops during the warmer months were not as great, and additionally occurred at a higher initial temperature than those during the cooler months. Most significant temperature drops occurred with the passage of a cold front, but not with all fronts, especially those coming earlier in the season. Therefore, since migration was positively correlated with falling minimum temperature only in the last half of 1961, it seems possible that this condition has some importance later in the migration period. If this is true, temperature may have a gradual cumulative effect, much like that postulated by Weise (1956) for the spring migration of three species of sparrows (but, of course, cumulative in the opposite direction). It is possible then, as Hinde (1951) suggested, that the relative importance of any weather factor varies with other factors. It is also possible, that since temperature drops were generally concurrent with cold fronts, the birds were actually responding to the fronts or to the wind shift accompanying them. In this case the influence of falling temperature would mask the actually higher relative importance of the other factors.

The data appear to indicate that a clockwise wind shift toward north is the primary or even sole weather stimulus to continuing migration for shorebirds in the Midwest, supporting the suggestion of Hassler et al. (1963) concerning passerines. Although correlation with cold fronts was high, that with wind was higher in all cases. Since such a wind shift occurs almost always when a front passes (but sometimes it occurs without frontal passage), cold front passage may have a masking effect on the relation, like that of temperature discussed above. That is, the birds appear to be responding to a cold front when it passes, but they are in actuality responding to the wind shift accompanying it. This is illustrated by the fact that in October 1960 the mean number of birds migrating during the two periods when cold fronts passed without a wind shift was 3.5, while the mean for birds migrating in the two periods with a wind shift but no front was 5.0. The overall volume of migration in October was higher during the time of the two former periods than when the two latter periods occurred. Thus, percentagewise these two means are actually more different than they appear as absolute figures.

Frequently there were times when the number of various species did not change from one observation to the next (see Figs. 1 and 2). It is assumed that this indicated no migration, although it is possible that movement out

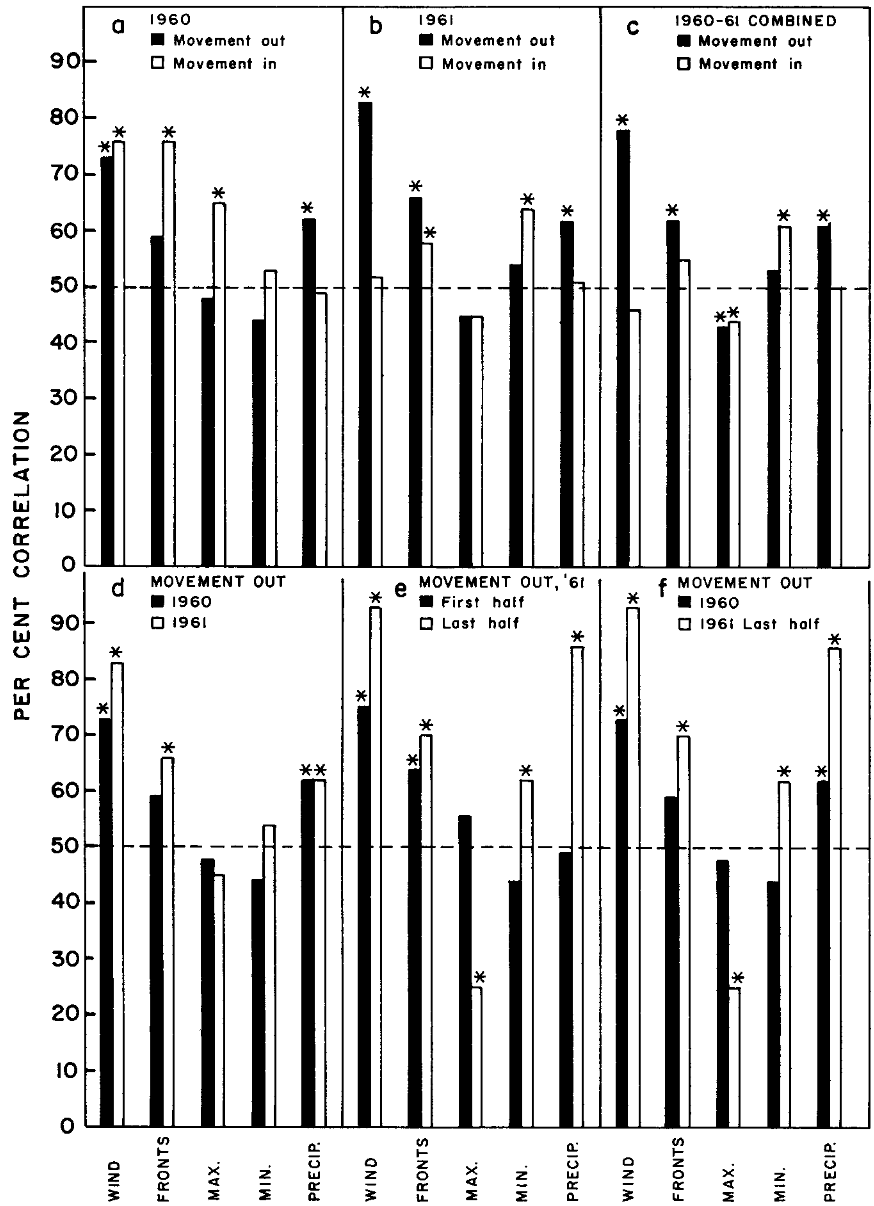

FIG. 3. Per cent correlation between autumn migration of shorebirds and wind shifts toward north, cold fronts, falling daily maximum and minimum temperatures, and precipitation. Starred bars indicate significant positive or negative correlation ($p \leq 0.02$), depending on whether the value is above or below the 50% line.

compensated exactly for movement in. Of the periods when birds showed no movement the following was determined:

a) wind shift toward north occurred in 75%;
b) cold front passage occurred in 70%;
c) precipitation occurred in 63%;
d) falling minimum temperature occurred in 37%;
e) falling maximum temperature occurred in 34%.

This may indicate that the birds must be physiologically ready to migrate, and unless they are, weather conditions have little influence.

The amount of time that birds remained at the pond varied from 1 to probably about 12 days (possibly 20 days or more for certain Stilt Sandpipers in 1960). The durations were determined by examination of the movements (Figs. 1 and 2) and by observations made on certain individuals with distinctive markings (e.g., one, a slightly melanistic Lesser Yellowlegs). The average stay for several of these individuals was 5 days, but it is probable that the average for all birds was somewhat less. A combination of factors probably determined the length of the stay, including weather conditions, the internal state of the birds, and feeding conditions.

Very little correlation could be attempted between other weather conditions and migration. Subjective observation, however, indicated that overcast and high winds both apparently inhibited migration.

SUMMARY

Comparisons of autumnal shorebird migration with weather showed that in the first half of migration movements out of the study area were correlated only with wind shifts toward north and cold front passage, correlation with wind being higher. During the last half of migration, however, there was significant correlation with wind, cold fronts, falling daily minimum temperature, and precipitation, the influence of the last two factors increasing considerably. Precipitation was considered to have only an indirect effect by reducing feeding area and food availability.

It was concluded that a clockwise wind shift toward north was the primary stimulus to autumnal migratory movement of shorebirds in this area, the other weather factors being of indirect or secondary importance, and having a masking effect on this relation.

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