REVERSE MIGRATION

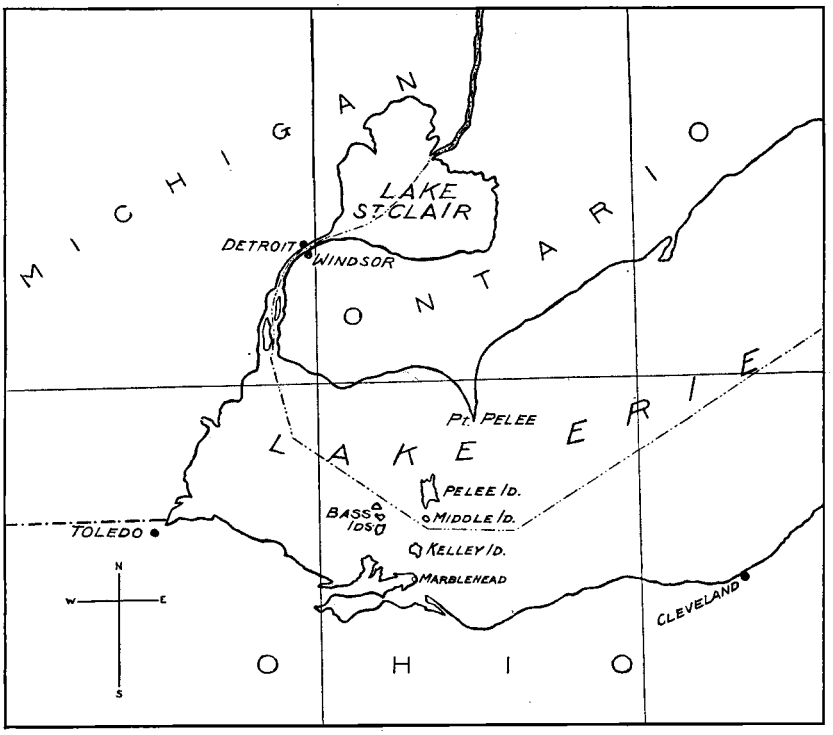
BY HARRISON F. LEWIS

ABOUT thirty-five miles east of the western end of Lake Erie, a series of islands, including Pelee Island, Kelley Island, Middle Island, and the Bass Islands, together with points jutting out from the mainland, both north and south, provides a natural route for those migrating land birds that have occasion to cross the lake in this vicinity. The special suitability of Point Pelee, at the northern end of this route, for observation of migrating birds is already well known. Other stations possessing similar suitability are to be found at other points on this migration highway. These places are points of land opposite the shortest available crossings over water, for at such places migrants occur in greater concentration and with more conspicuousness than is usual elsewhere.

During the period from the evening of May 10, 1937, to the evening of May 14, I had the opportunity to observe migration on Pelee Island. This, the largest island in Lake Erie, is a part of Essex County, Ontario. It is situated in latitude 41° 45′ north and longitude 82° 40′ west, about eight and a half miles southwest of Point Pelee and about twelve miles, slightly east of north, from the nearest part of the mainland of Ohio. It extends about eight miles from north to south and three and a half miles from east to west and is of slight elevation. A large part of the island is under cultivation, but there are also numerous small wooded areas. At the southwestern angle of the island, a low, narrow ridge of sand, about one and a half miles long, known as Fishing Point, extends southward toward Middle and Kelley Islands. This point is well wooded with mixed deciduous trees and red cedars for a distance of more than a mile from its base. The southern part of this tree-covered area becomes very narrow before it terminates in a rather dense growth of red cedar, wild cherry, sycamore and wild grape, beyond which a bare sandy spit projects southward for several hundred yards. A more detailed description of Pelee Island, and of Fishing Point in particular, has been published by Jones (17).

During the four days that I spent on Pelee Island in 1937, I visited Fishing Point daily. On May 11, 12, and 14, I made my visits to it in the early morning; on May 13 I visited it a little before noon. Interesting observations were made on this point every time I went there, but this paper is concerned particularly with observations of migration on May 12, which were very different from those made on my other visits. May 11, 1937, was a fine, sunny spring day on Pelee Island. Barometric pressure declined from 30.31 inches at 7.00 a. m. to 30.17 at 5.45 p. m. The temperature rose from 50° F. at 7.00 a. m., to a maximum of 66° (2.00 p. m. to 3.40 p. m.)

and was 61° at 5.45 p. m. A calm that lasted most of the morning was broken a little before noon by a light southwest wind, which was followed by a brisk southeast wind that blew throughout the afternoon. At 7.00 a. m. on May 12, a fresh wind was blowing from south at the rate of fifteen miles an hour. The sky was partly cloudy and the air was hazy, with 'visibility' for air navigation rated at six miles. The barometer stood at



TEXT-FIG. 1.—Map of western part of Lake Erie and adjacent region.

29.97, the thermometer at 57°. Similar conditions characterized most of the day. The barometric pressure, by 10.50 a. m., had reached a minimum of 29.92, from which there was no significant rise until late in the afternoon. Temperature reached a maximum of 61° at mid-day and was down to 57° at 5.45 p. m. The wind veered to southwest in the latter part of the morning and blew freshly until after four o'clock, when it lessened rapidly. The maximum rate recorded was twenty-five miles an hour at 12.45 p. m. There were light showers near noon and also between four and five o'clock.

At 6.45 a. m., when I arrived at the last trees on Fishing Point, I noticed in the tree-tops a number of Red-headed Woodpeckers and Baltimore

Orioles, with two Orchard Orioles, and supposed that they were recent arrivals from the south, pausing there to rest. In a few moments, however, I was forced to realize, to my astonishment, that the direction of bird flight at that time and place was from north to south, instead of toward the north, and that many birds were participating, singly or in flocks, in this movement. There was an almost continuous stream of warblers and other small birds coming along the point from somewhere north of me and flitting unsteadily out over the rough water toward Middle Island, dimly visible to the southward. At frequent intervals flocks of Cedar Waxwings, Goldfinches, Pine Siskins, and birds that I now believe to have been Pipits swept along the same route. Most of these did not pause in the last trees, but the waxwings often settled there for a minute or less before flying out over the lake. Orioles and Red-headed Woodpeckers made a common practice, I found, of staying in the last trees for several minutes before continuing their southward flight. Those that I saw in the trees when I arrived at the end of the woods were merely the southbound individuals that happened to be resting there at the moment. Baltimore Orioles kept coming from the north, one at a time, so frequently that there were almost always some of them pausing in the last trees.

Most of the birds, once they had left the shelter of the trees, had difficulty in making headway against the wind, but they generally persisted in flying south, rising higher and higher over the lake as they went. Only the Barn Swallows maintained, as they flew, a low elevation, within a foot or two of the wave crests. Despite the adverse conditions, very few birds were seen to turn back, but one flock of Cedar Waxwings, a few groups of Starlings, and a few individual Red-headed Woodpeckers were observed to do so. It seemed as though the bird population of Pelee Island, if not also of regions farther north, were draining away and as if the birds were possessed with an irresistible madness that, in spite of all obstacles and dangers, was driving them southward in the very flowering of the spring. For some time I found it difficult to identify specifically many of the warblers in the stream of them that was flitting past me, but after a while I discovered that, by going north about fifty yards from the last trees, to a place where the line of trees (red cedars and cherry trees) was still narrow, I could observe and identify the warblers well, for on that part of the point they were not making continuous flight, but were travelling southward by flying from tree to tree, feeding as they went.

The southward movement of birds continued undiminished during the two hours, from 6.45 a. m. to 8.45 a. m., that I spent on the outer part of Fishing Point on May 12 and was proceeding without abatement when I departed. When I had left the point entirely and was walking north along the western side of Pelee Island, toward the West Dock, I was passed at

intervals, up to 11.00 a. m., by flocks of Cedar Waxwings and Goldfinches, flying steadily south at low elevation. No birds migrating southward were noticed on the afternoon of May 12, when I was observing birds along the west side of Pelee Island north of West Dock.

There follows an annotated list of the thirty-five species of birds that were seen to take part, near the last trees on Fishing Point, in the southward flight that occurred on the morning of May 12, 1937.

EASTERN MOURNING DOVE, *Zenaidura macroura carolinensis.*—One group of three.

CHIMNEY SWIFT, *Chaetura pelagica.*—One or two.

RED-HEADED WOODPECKER, *Melanerpes erythrocephalus.*—Four or five were in the last trees when I arrived near them, at 6.45 a. m. These remained there for a while and additional individuals straggled in from the north and joined the group until 7.30 a. m., when nine or ten birds of this species were present. Then they all flew away to the south. Subsequently others kept straggling out through the trees and flying south.

EASTERN KINGBIRD, *Tyrannus tyrannus.*—Several individuals, straggling along singly, took part in the movement. They usually paused for a time in the tops of the last trees before flying out over the lake.

TREE SWALLOW, *Iridoprocne bicolor.*—One.

ROUGH-WINGED SWALLOW, *Stelgidopteryx ruficollis serripennis.*—One.

BARN SWALLOW, *Hirundo erythrogaster.*—Two.

NORTHERN BLUE JAY, *Cyanocitta cristata cristata.*—Two.

(AMERICAN PIPIT, *Anthus spinoletta rubescens.*—Several southward-flying flocks of small brownish birds that, in the rush of events, were not identified at the time were probably of this species. A flock of Pipits was identified in a plowed field on Pelee Island on May 13.)

CEDAR WAXWING, *Bombycilla cedrorum.*—Numerous flocks of from twenty to fifty birds each, formed a conspicuous part of the southward-bound throng. The total number of individuals in the flocks actually seen, is believed to have been more than five hundred. The flocks often paused for a minute or less in the last trees.

STARLING, *Sturnus vulgaris vulgaris.*—Fifteen or more, in small groups.

BLUE-HEADED VIREO, *Vireo solitarius solitarius.*—One.

EASTERN WARBLING VIREO, *Vireo gilvus gilvus.*—Three.

NASHVILLE WARBLER, *Vermivora ruficapilla ruficapilla.*—A dozen or so, straggling.

EASTERN YELLOW WARBLER, *Dendroica aestiva aestiva.*—Several.

MAGNOLIA WARBLER, *Dendroica magnolia.*—Two or three.

CAPE MAY WARBLER, *Dendroica tigrina.*—Several.

MYRTLE WARBLER, *Dendroica coronata.*—Very many. The numbers of this species were estimated to be at least half of the total number of warblers observed. Myrtle Warblers often paused for a time in the last trees.

BLACK-THROATED GREEN WARBLER, *Dendroica virens virens.*—Many.

CERULEAN WARBLER, *Dendroica cerulea.*—Two.

BLACKBURNIAN WARBLER, *Dendroica fusca.*—Many of both sexes.

CHESTNUT-SIDED WARBLER, *Dendroica pensylvanica.*—Many adult males.

BAY-BREASTED WARBLER, *Dendroica castanea.*—Several.

BLACK-POLL WARBLER, *Dendroica striata.*—Two.

AMERICAN REDSTART, *Setophaga ruticilla.*—Two, one being an adult male and the other a female or a male of the previous year.

WOOD WARBLERS, *Compsothlypidae*, not specifically identified.—Large numbers.

ENGLISH SPARROW, *Passer domesticus domesticus*.—One.

BOBOLINK, *Dolichonyx oryzivorus*.—Twenty-five or more, straggling.

EASTERN RED-WING, *Agelaius phoeniceus phoeniceus*.—Several adult males, straggling.

ORCHARD ORIOLE, *Icterus spurius*.—Two adult males that were in the tops of the last trees at 6.45 a. m., when I arrived near them, flew south a few minutes later. After an interval, a male of the previous year alighted in one of these trees, remained there for a few minutes, then flew southward. No other individuals of this species were recognized.

BALTIMORE ORIOLE, *Icterus galbula*.—Many of both sexes were seen passing southward. They straggled down the point at frequent intervals and generally paused for several minutes in the tops of the last trees before they flew south over the lake.

BRONZED GRACKLE, *Quiscalus quiscula aeneus*.—Several, straggling.

INDIGO BUNTING. *Passerina cyanea*.—At least two males were seen flying south, passing the last trees without stopping. Two other males were seen later in the woods a short distance north of the last trees.

NORTHERN PINE SISKIN, *Spinus pinus pinus*.—A good many flocks, each containing from ten to fifty birds, passed southward over the point without stopping in my vicinity. It is estimated that the total number of individuals in these flocks was not less than three hundred.

EASTERN GOLDFINCH, *Spinus tristis tristis*.—Frequent flocks, each containing from five to twenty birds, passed the last trees without stopping. The total number of individuals seen is believed to have been not less than one hundred fifty.

EASTERN GRASSHOPPER SPARROW, *Ammodramus savannarum australis*.—One.

It would be interesting to know the localities in which this southward-bound stream of birds originated. On May 11, an ideal day for observing birds, I had visited Fishing Point in the early morning and had traveled extensively over Pelee Island later in the day, by automobile and on foot. Yet on that day I saw no Cedar Waxwings or Pine Siskins, species that were going south from Pelee Island in hundreds on the morning of May 12. On May 11, I saw of Goldfinches only five, of Baltimore Orioles only two, and of Red-headed Woodpeckers only two, yet these species ranked as common to abundant in the southbound flight of birds on the following morning. Whence did they come? They may have been on Pelee Island on May 11 without my noting any indication that they were so numerous there, but I do not think so. Did they arrive from the south in the night of May 11–12, only to turn back across the southern part of Lake Erie after daylight on the morning of the 12th, or did they come to Pelee Island from the mainland on the north, either during the night of May 11–12 or on the following morning, shortly before I saw them at Fishing Point? Had other observers of migration been stationed, on the morning of May 12, at other points along this migration route, so that observations of bird movements at several places, from one side of the lake to the other, could have been made

simultaneously, we might be able to answer this question and others of interest.

The list of species that participated in this southward flight presents several features of particular interest. It contains not only species that were then transients in the region, such as the various warblers, and late-nesting species, such as the Goldfinch and the Cedar Waxwing, but also representatives of species most of whose local resident individuals were at that time well advanced in nesting activities. In this group may be included the Mourning Dove, Starling, English Sparrow, Eastern Red-wing, and Bronzed Grackle. It is also worthy of note that many of the birds taking part in full daylight in this southward movement across broad water areas were of weak-flying types, such as vireos, warblers, and orioles, which are commonly believed to make extended migratory flights only at night.

The absence from this list of various species of birds that were then common in the region in which these observations were made, is also interesting. Species of land birds that were observed to be common on Pelee Island on May 11–12, 1937, but that were not seen to participate in this southward movement are the following:

RING-NECKED PHEASANT, *Phasianus colchicus torquatus*.—Nesting birds.

EASTERN CROW, *Corvus brachyrhynchos brachyrhynchos*.—Presumably nesting birds.

EASTERN HOUSE WREN, *Troglodytes aëdon aëdon*.—Probably both transients and local residents.

EASTERN ROBIN, *Turdus migratorius migratorius*.—Doubtless nesting birds.

OLIVE-BACKED THRUSH, *Hylocichla ustulata swainsoni*.—Transients.

EASTERN RUBY-CROWNED KINGLET, *Corthylio calendula calendula*.—Transients.

BLACK AND WHITE WARBLER, *Mniotilta varia*.—Probably both transients and local residents.

WESTERN PALM WARBLER, *Dendroica palmarum palmarum*.—Transients.

NORTHERN YELLOW-THROAT, *Geothlypis trichas brachidactyla*.—Probably both transients and local residents.

EASTERN MEADOWLARK, *Sturnella magna magna*.—Presumably local residents.

EASTERN COWBIRD, *Molothrus ater ater*.—Presumably local residents.

EASTERN CARDINAL, *Richmondena cardinalis cardinalis*.—Residents, probably nesting.

WHITE-CROWNED SPARROW, *Zonotrichia leucophrys leucophrys*.—Transients.

WHITE-THROATED SPARROW, *Zonotrichia albicollis*.—Probably transients only.

SONG SPARROW, *Melospiza melodia* (subsp.?).—Probably residents only.

With the exception of the Myrtle Warbler, warbler species that were common in the southbound flight on the morning of May 12, including undoubted transients, were numerous on Pelee Island throughout the day. A marked 'wave' of migrating warblers was present. In the afternoon, in woods northeast of West Dock, Blackburnian, Black-throated Green, Nashville, and Magnolia Warblers were especially plentiful. Myrtle War-

blers, though particularly numerous in the southbound throng on the morning of May 12, were not found by me on Pelee Island in the afternoon of that day.

Some outstanding students of bird migration have held the opinion that the wind, unless so high as to be unfavorable from its very strength and turbulence to any migration, exercises little influence upon the progress of migratory flights. Thus Eagle Clarke (11, 1: 178) says: "The importance of winds in connection with bird-migration has been much overestimated, and their bearing upon the phenomenon, such as it is, greatly misunderstood. Their direction, apart from the weather conditions to which they are due, has no influence whatever on the movements." Cooke (5) states that "during spring migration the direction of the wind seems to have little if any effect on the arrival of the birds." Thomson (29, p. 105) concludes his consideration of this matter with the following remark: "Examples might be multiplied, but all would lead to the same conclusion that the direction of the wind is an unimportant factor, and that when migrants travel with the wind it is a coincidence—the migration and the wind are not directly related, but are respectively influenced and caused by the pressure conditions at the point of origin." Wetmore (34, p. 56), while giving little consideration to this question, says: "The northward flight of migrants in general is initiated when wind and temperature are favorable."

During the last decade, following the establishment of permanent stations for scientific study of bird migration at several favorably located places on the continent of Europe, a good deal of attention has been paid, especially by ornithologists of Holland and Germany, to the relation between bird migration and the wind. It has been observed that some birds, such as the Hooded Crow, *Corvus cornix*, and the Rook, *C. frugilegus*, migrate with little regard to weather conditions, while the migrations of a great many birds are much influenced, in one way or another, by the weather. Weigold (32) has proposed the term 'instinct birds' for those birds that migrate regularly, no matter what the weather, and the term 'weather birds' for those whose migrations the weather affects. Koch (18) has termed the relation between the direction of bird migration and the direction of the wind 'anemotaxis' and has divided the 'weather birds' into the 'positively anemotactic,' which tend to fly contrary to the direction of the wind, and the 'negatively anemotactic,' which tend to fly with the wind. When the direction in which the wind blows is exactly the direction normal for the migration and the positively anemotactic birds, flying directly into the wind, migrate directly away from their presumed destination, the phenomenon is termed '*cursus retroversus*.' Koch cites numerous examples of such occurrences, observed by him and others in Holland and Germany. His detailed account of the relation of bird migration to the wind is said to be based on ten years' ob-

servations on the coast of Holland and to be corroborated by the practical experience, extending over a much longer period, of the professional bird-catchers of that region. His examples are selected from observations of autumn migration.

Reverse flights in spring of certain European passerine birds, including at various time fringillids, wagtails, pipits, starlings, thrushes, redbreasts, and larks, are described by Poncy (23) and by Natorp (21, 22). These cases, however, appear not to be characterized by flight against a wind blowing in the normal direction of migration, but to be due to the fact that the migrants concerned had, in their progress northward, encountered low temperatures, snow, or other unfavorable weather conditions, which forced them to make a temporary retreat. Such instances have been distinguished in Europe under the term 'retromigration' and should not be confused with '*cursus retroversus*,' as defined in the preceding paragraph.

While it would be rash to attempt to form or to present, on the basis of a single observed instance, a theory as to the cause of the apparent tendency of some birds to fly against the wind or the way in which the cause produces the effect observed, yet the known facts in connection with the occurrence of *cursus retroversus* at Pelee Island on May 12, 1937, do seem to afford grounds for certain comments on the general subject and on some of the theories about it that have already been advanced. Drost and Bock (9), for example, speaking of instances of *cursus retroversus* in autumn migration, when birds whose normal course in that migration was southwest flew northeast against a northeast wind, express the view that this occurrence was not due merely to the fact that there was a northeast wind, but to the fact that this wind, as an exception, brought with it warm masses of air. It is apparently their idea that autumn migrants instinctively seek warmer regions and are therefore influenced to fly toward a warm wind, even when it blows from the northeast. That is, they would attribute *cursus retroversus* to a reversal of normal temperature change and of normal geographical distribution of air temperatures. Normal migration flights in spring are generally accompanied by rising temperature at the point of departure and produce progress into regions where the temperature is lower than at that point. Normal migration flights in autumn, on the contrary, are generally accompanied by falling temperature at the point of departure and produce progress into regions where the temperature is higher than at that point. Temperature conditions that may play a part in occasioning migratory flights must be only those at the point of departure, but, once the migrants are in flight, normal temperature changes as they advance may conceivably induce them to continue until a normal flight is completed. If *cursus retroversus* is due to a reversal of normal temperature change and of normal geographical distribution of air temperatures, then in spring it should be ac-

companied by a falling temperature at the point of departure and should be a movement southward through regions of successively lower temperatures. But the temperature on Pelee Island at 7.00 a. m. on May 12, 1937, was 7° F. higher than it was at the same hour on the preceding day. The weather map of the United States Weather Bureau for May 12 states, concerning the twenty-four hours previous to 7.30 a. m.: "The temperature has risen from the Mississippi Valley eastward to the Atlantic coast." The mean between maximum and minimum temperatures on Pelee Island on May 12 was 60° F., while the corresponding mean at Sandusky, Ohio, sixteen miles to the south, was 65° F., or 5° higher. The birds that I saw migrating southward in the time of spring migration were setting out in a period of rising temperature and were proceeding to a region of higher temperature. My observations do not, therefore, support the above-mentioned theory of Drost and Bock.

In the same paper these authors suggest that *cursus retroversus* may be understood only in case the sky is overcast, so that the migrating birds cannot see and be guided by the positions of the heavenly bodies, or in case, in the species affected, reaction to the visible positions of the heavenly bodies is non-existent or is overcome by some stronger reaction. Koch (18), commenting on this view, states that *cursus retroversus* often occurs at Wassenaar, in the Netherlands, on sunny days. During the time of my observation of this phenomenon on May 12, 1937, the sky was partly clouded and the sun was not visible.

The possible relation of *cursus retroversus* to barometric pressure, especially to its geographical distribution, may be considered. The principal center of the area of low pressure in which Pelee Island was included on May 12, 1937, had a pressure of 29.4 and was, at 7.30 a. m., near Sioux Lookout, Ontario, 780 miles distant from Pelee Island in a direction somewhat north of northwest, and was moving toward the east. There was a lesser center, with a pressure of 29.8, near Oklahoma City, Oklahoma, about 900 miles distant toward the southwest. There was a center of high pressure, with a maximum of 30.3, over the Atlantic Ocean not far east of Atlantic City, New Jersey, or 500 miles distant to the east-southeast, and another high-pressure center, with a maximum of 30.2, near Concord, New Hampshire, or 575 miles distant toward the east-northeast. The birds that I saw flying south from Pelee Island were not directing their course toward any of these high or low centers. They were not fleeing from a stormy area, for there was no stormy weather anywhere within 200 miles to the northward of Pelee Island and the northern center of low pressure was taking a course that would not bring it within 500 miles of the island. If they maintained their southward course for a few miles, these birds would experience slightly lower pressure, for the barometric pressure at Sandusky, Ohio, at 7.30 a. m.

was 29.88, which may be compared with Pelee Island barometric pressures of 29. 97 at 7.00 a. m. and 29.92 (minimum for the day) at 10.50 a. m., 12.45 p. m., and 3.40 p. m. It does not, however, appear possible for a bird, whether remaining stationary or making short local flights, to have any perception of the direction in which an area of barometric pressure lower or higher than that at the bird's position is to be found. Unless and until it is shown that a bird may have a perception of a different barometric pressure at a distance in a particular direction, any assumption that it is capable of this kind of perception is unwarranted and it is not useful to try to make it the basis of theories about the phenomenon of *cursus retroversus*. There is a possibility that the condition of falling barometric pressure that existed on Pelee Island on the morning of May 12 may have had something to do with the occurrence of a reverse migration, but if such a condition regularly produces such a result we should expect reverse migration to be far more common than it appears to be. It may also be noted that, although the barometric pressure on Pelee Island on May 11, 1937, fell from 30.31 at 7.00 a. m., to 30.17 at 5.45 p. m., and on May 13, after rising slightly from 30.01 at 7.00 a. m., to 30.04 at 10.55 a. m., diminished slowly to 29.98 at 5.45 p. m., my observations on the island, including those made during daily visits to Fishing Point, failed to show any southward flight on either of these days. Both days were calm throughout most of the morning. On May 11, a brisk southeast wind blew during the afternoon and on May 13 there was a light north wind at 4.40 p. m. and 5.45 p. m. May 11 was bright and sunny; on May 13 the sky was almost entirely overcast.

As to the view advanced by Koch (18), that there exists such a relation as anemotaxis, or a connection between the direction of the wind and the direction of bird migration, and that positive anemotaxis, or a tendency for certain birds to migrate against the wind, may, on occasions when the wind blows in the direction in which migration normally takes place, result in the occurrence of *cursus retroversus*, or migration in a direction opposite to the normal one, the following remarks may be offered. A bird resting on a perch may be, and presumably is, aware of the direction of the wind in much the same way that we are, namely, through feeling the pressure of moving air against its windward side. There is therefore no difficulty in understanding how a bird may start to fly against the wind. Once the bird has loosed from stationary objects and launched into the air, its relation to the wind is greatly changed. It is then supported by the stream of air surrounding it and has no solid attachment to anything. It cannot then apprehend the direction of the wind by any pressure of the latter against its body, for, aside from the possible effect of turbulence, the air pressure against its body would be the same on all sides if the bird allowed itself to be swept along as an inert object in the air current. By its own efforts in flying ahead through

the surrounding air, the bird causes increased pressure against its forward side, but this result is obtained indifferently and to the same extent whether the bird directs its flight with, or against, or across a uniform stream of air. Except under unusual circumstances, the flying bird therefore presumably has no awareness of the direction or the velocity of the wind or of the direction or velocity of its own movement in relation to the surface of the earth or in relation to the direction or velocity of the wind unless it can perceive some fixed points on the earth or, for knowledge of direction but not of velocity, some recognizable heavenly body or bodies. It may also be presumed that it usually has such awareness as a result of seeing the surface of the earth. Anemotaxis in any form is, of course, not due to the effect of the wind on the plumage of the bird concerned, for a wind, whether favorable or contrary, will not ruffle the plumage of a freely air-borne bird any more than calm air will, for in either case the bird and the surrounding air do not move in relation to each other except as the bird propels itself or falls through the air. Turbulence may, it is true, have at times a slight effect, but it is very doubtful if, in the case of a moderate wind in the open, turbulence is sufficient to disarrange the plumage of a flying bird or to cause it to fly in a particular direction. When a steamship and the wind are proceeding in the same direction with the same velocity, the air on deck seems very still. One may then note that there is no effect of turbulence sufficient to stir the flag that hangs idly against its staff or to prevent innumerable light flakes of soot from showering gently down upon the ship. I know of no factual grounds for attributing to turbulence the power of producing a significant disturbing effect on birds making long flights except when the wind is of such high velocity that most small land birds do not undertake such flights. That turbulence is more disagreeable or more helpful to a bird flying in any particular relation to the direction of the wind than to that bird flying in any other relation to that direction still appears to be merely hypothetical. Manifestations of anemotaxis are, therefore, probably not possible unless the bird in flight can see the surface of the earth and thus have awareness of the direction of the wind and of its own progress in relation to the wind and to fixed objects.

Acworth (1) has assumed that birds migrating across the sea head continously for a fixed although unseen location and has shown that, in such circumstances, birds flying in a wind that is not either directly against or behind them would necessarily follow a curved path and finally arrive at their destination exactly head to the wind. Whatever validity this idea may possess, the reverse migration that I have described was not due to the conditions to which he refers. The wind at Pelee Island on the morning of May 12, 1937, was moving exactly in the direction in which migration at that place should normally be moving at that season. It may be noted al-

so that many of the birds that were flying south from Pelee Island that morning, such as the Blue-headed Vireo, Magnolia Warblers, Cape May Warblers, Myrtle Warblers, Bay-breasted Warblers, Black-poll Warblers, and Pine Siskins, do not nest in the regions lying southward from that island and therefore were not heading toward the destination of their migration. Neither were these birds merely in the situation described by von Holst (15), who has pointed out that a bird endeavoring to follow a fixed course while flying with a side wind can succeed in its attempt only by turning the axis of its body to some extent toward the wind, in order to offset drift or leeway. In the first place, a bird flying under the conditions described by von Holst will never be heading directly into the wind, but always in a direction intermediate between the direction in which it is actually progressing and the direction from which the wind is blowing. In the second place, these conditions can never cause a bird to head in a direction making an angle of more than 90° with its true course. Any wind striking the bird at an angle with its yet-to-be-traversed route that exceeds 90° contains a favorable component and the greater this component the smaller will be the angle between the axis of the bird's body and the line of the route to be traversed. Finally, the resultant of forces under these conditions will be progress directly along the bird's normal migration route, unless the velocity of the wind is greater than the bird's speed through the air, in which case the bird will be blown down wind. Therefore it is impossible for conditions such as those the existence of which is assumed by von Holst to produce *cursus retroversus*, or to cause birds to head in a direction within 90° of the direction of a reverse flight, or to cause them to fly exactly against or with the wind in any direction.

In the case of the numerous warblers of various species that I found moving southward against the wind by flitting from tree to tree on the densely wooded part of Fishing Point, where the thick foliage of the red cedars provided abundant shelter from the force of the wind, it is evident that the apparent anemotaxis thus displayed was not primarily, if at all, a utilization of any possible physical advantages to be found in flying against the wind nor an avoidance of any possible physical disadvantages or risks to be incurred by flying with the wind. In the sheltered spaces among the evergreens the birds were physically free to flit in one direction as well as in another. The fact that they were, nevertheless, moving continually southward against the wind, toward the last trees on the point, whence their southward journey was continued by a long flight in the open, appears to indicate either that their orientation was not governed by the wind or, what I deem more probable, that such movement to windward is not now directly related to any possible favorable physical factor or factors connected with flight against the wind, but points to some instinctive reaction to wind

direction that, under certain conditions, may be irrepressible in many birds and that, whatever its origin, may at times lead to flight that is more or less disadvantageous and even risky to the birds that perform it.

It seems to me that my observation of *cursus retroversus* is not out of harmony with the theory of Koch and that there are serious objections to the alternative ideas that have been proposed. Why and how some birds may be so influenced by the direction of the wind that they migrate directly against it, even when this involves reversing their normal course, and why all the individuals of a species in a given region at a given time do not behave alike in this regard are questions requiring thorough investigation. (Lorenz (20) has advanced very plausibly the idea that birds have a psychological dislike for flying with the wind, at least at low elevations, because then, like a motorboat running down a stream with a swift and turbulent current, their course is difficult to control, they cannot stop at will nor even advance slowly, and they must turn around and face against the current before they can make a safe landing. Reasons for not flying with the wind are, however, not necessarily reasons for flying directly against the wind.) There is also need to reconcile observations on bird migration in relation to the wind, including observed instances of *cursus retroversus*, with other observed facts of migration, including the regular annual arrival of some migrant species and the repeated return of individual birds to the same breeding areas and wintering grounds. Even a partial solution of these problems will probably improve our comprehension of the factors that govern the orientation and progress of bird migration in general.

The fact that reverse migration is so little known in North America is due, I believe, to failure to give special attention to continued studies of bird migration at the favored points where natural conditions cause migratory activity to be concentrated, frequent, and comparatively easy to observe. The establishment in Europe of permanent, well-equipped stations for the purpose of studying bird migration at favored places of this kind soon had for one of its results a realization that reverse migration is by no means rare and that its significance should be carefully investigated. If a line of research stations could be established along the Point Pelee—Pelee Island—Ohio migration route or at other places of equal suitability and an intensive, cooperative study of migration carried on, there is little doubt that valuable data would accumulate rapidly and that a great deal of new light would be thrown, not only on the problem of reverse migration, but also on many of the other puzzling questions relating to the migration of birds.

REFERENCES

1. ACWORTH, B. This Bondage. London, 1930.
2. BOUMA, J. P., KOCH, J. C., EN VAN MALSSEN, J. F. M. Jaarverslag van het Ring-station Wassenaar 1927–28. Ardea, 18: 38–57, 1929.
3. BOUMA, J. P., EN KOCH, J. C. Voorkomen en Trek van Sijzen. Orgaan Club van Ned. Vogelk., 6: 63.
4. CHRISTOLEIT, E. Vogelflug und Luftbewegung. Journ. f. Ornith., 81: 388–398, 1933.
5. COOKE, WELLS W. The relation of bird migration to the weather. Auk, 30: 205–221, 1913.
6. VAN DOBBEN, W. H., UND MAKKINK, G. F. Der Einfluss der Leitlinien auf die Richtung des Herbstzuges am niederländischen Wattenmeer. Ardea, 22: 30 ff., 1933.
7. DROST, R. Ueber Vogelwanderungen in den Wintermonaten. Verh. des VI Int. Ornith. Kongress, 1926.
8. DROST, R. Ueber den Vogelzug auf der Schlangeninsel im Schwarzen Meer. Abh. a. d. Gebiet der Vogelzugsforschung, no. 2, 42 pp., 1930.
9. DROST, R., UND BOCK, EB. Ueber den Vogelzug im Nordseegebiet. Der Vogelzug, 2: 79 ff., 1931.
10. DROST, R. Zug gegen den Wind bei Finkenvögeln. Der Vogelzug, 2: 113, 1931.
11. EAGLE CLARKE, WILLIAM. Studies in bird migration. London, 1912.
12. GEYR VON SCHWEPPENBURG, H. FRHR. SO-NW-Zugstrasse durch die Sahara? Journ. f. Ornith., 72: 102–108, 1924.
13. GEYR VON SCHWEPPENBURG, H. FRHR. Zug bei starkem Gegensturm. Der Vogelzug, 2: 110, 1931.
14. GEYR VON SCHWEPPENBURG, H. FRHR. Gegenwindzug ? Journ. f. Ornith., 81: 399–407, 1933.
15. VON HOLST, ERICH. Nochmals: Vogelzug und Gegenwind. Der Vogelzug, 2: 163–166, 1931.
16. JONES, LYNDS. The birds of Cedar Point and vicinity. Wilson Bull., 21: 55–76, 115–131, 187–204, 1909; 22: 25–41, 97–115, 172–182, 1910.
17. JONES, LYNDS. A study of the avifauna of the Lake Erie islands. Wilson Bull., 24: 6–18, 95–108, 142–153, 171–186, 1912.
18. KOCH, J. C. Vogelzug unter Einfluss von Leitlinie und Windrichtung. Der Vogelzug, 5: 45–52, 1934.
19. KRÄTZIG, HEINRICH. Der Frühsommerzug des Stars auf der Windenburger Ecke. Der Vogelzug, 7: 1–16, 1936.
20. LORENZ, KONRAD. Fliegen mit dem Wind und gegen dem Wind. Journ. f. Ornith., 81: 596–607, 1933.
21. NATORP, OTTO. Nachtrag zur Kreuzschnabelinvasion 1930. Der Vogelzug, 2: 40, 1931.
22. NATORP, OTTO. Rückzugbeobachtung im Frühjahr 1931. Der Vogelzug, 3: 72–74, 1932.
23. PONCY, R. A propos des "Retromigrations" d'oiseaux observées durant le mois de mars à la station ornithologique du Port de Genève. Der Ornith. Beobachter, 28: 149–151, 1931.
24. RIVIÈRE, B. B. A history of the birds of Norfolk. London, 1930.
25. SCHENK, J. Die Prognose des Frühjahrszuges der Waldschnepfe in Ungarn. Proc. VIIth Int. Congr. at Amsterdam, p. 357, 1930.

26. SICK, H. Tageszug der Bekassine (*Capella gallinago*) (L.) 1931 am Kurischen Haff. Der Vogelzug, 6: 128, 1935.
27. TAVERNER, P. A., AND SWALES, B. H. The birds of Point Pelee. Wilson Bull., no. 59, pp. 37–54; no. 60, pp. 82–99; no. 61, pp. 133–153; no. 63, pp. 79–96; no. 64, pp. 107–124, 1907–1908.
28. THIENEMANN, J. Rossitten, 1928, p. 294.
29. THOMSON, A. LANDSBOROUGH. Problems of bird-migration. London, 1926.
30. THOMSON, A. LANDSBOROUGH. Recent progress in the study of bird-migration: a review of the literature, 1926–35. Ibis, (13), 6: 472–530, 1936.
31. VERWEY, J., IN G. J. VAN OORDT EN J. VERWEY. Voorkomen en Trek der in Nederland in het Wild waargenomen Vogelsoorten. Inleiding, p. viii, 1925.
32. WEIGOLD, H. VII. Bericht der Vogelwarte der Staatl. Biologischen Anstalt auf Helgoland. Journ. f. Ornith., 72: 17–68, 1924.
33. WEIGOLD, H. Das Wetter und der Herbstzug der Waldschnepfe. Journ. f. Ornith., 72: 416–421, 1924.
34. WETMORE, ALEXANDER. The migrations of birds. London and Cambridge, 1927.
35. WOOD, N. A. Bird migration at Point Pelee, Ontario, in the fall of 1909. Wilson Bull., 22: 63–78, 1910.

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