HOMING FLIGHTS AND ORIENTATION OF PIGEONS

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In an earlier paper (Hitchcock, 1952) an account was given of the behavior of flocks of pigeons on homing flights as seen from an airplane. The present account deals with subsequent aerial observation of pigeons homing as singletons as well as in flocks, and with the initial orientation of the birds as observed from the ground. The investigations were made possible through the continued support of the American Philosophical Society, which is gratefully acknowledged. The Army Signal Corps through Mr. Otto Meyer, chief of the Pigeon Breeding and Training Center at Fort Monmouth, New Jersey, provided some of the birds and rendered other valuable assistance. The airplane flights were all piloted by Mr. Robert Hunt of Middlebury, and the aerial observations were made by him and the author jointly.

Fort Monmouth Birds

In 1950, directionally trained Fort Monmouth pigeons released in flocks homed well from the west, the direction in which they had been trained, but poorly when released north of the loft because of a tendency to fly eastward. In 1952, birds were released in the same places as in 1950, but as singletons. Some of them had been trained to home from the west, like the 1950 birds; others had been settled at the loft, i.e., allowed their freedom to fly outside the loft, but not trained; and some had never been permitted to fly outside the loft. These three types will be referred to as *trained*, *settled*, and *non-settled*, respectively. None of the birds used in 1952 had participated in the 1950 program. The places from which the trained birds had flown prior to the 1952 releases are shown in Figure 1.

The same general methods were employed as in 1950. It was found practical to increase the altitude of the plane to about 2000 feet above the birds. No attempt was ordinarily made to follow singletons more than an hour. To facilitate the reporting of strays, each bird wore on its leg, in addition to its number band, a conspicuous plastic capsule with a request that the finder notify the author of the time and place the bird was found. These messages proved to be of value, for of 49 Fort Monmouth birds lost in the 1952 flights, reports were received on 16, and 2 birds were reported twice. In 1950, 27 Fort Monmouth birds were lost, all banded but without message, and none was reported. The birds were taken by plane to the release points early on the day of the flight and liberated late in the morning

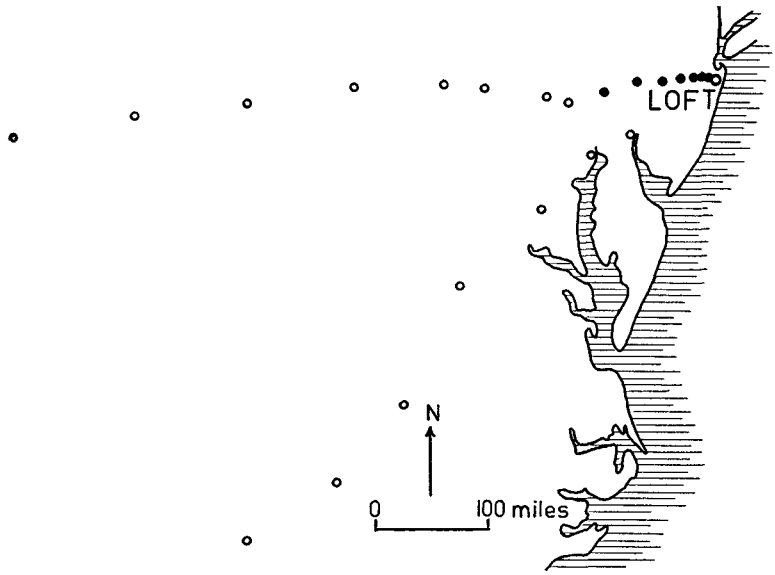


FIGURE 1. Release points from which trained Fort Monmouth birds had flown prior to experimental flights. Solid circles, training stations; open circles, racing stations.

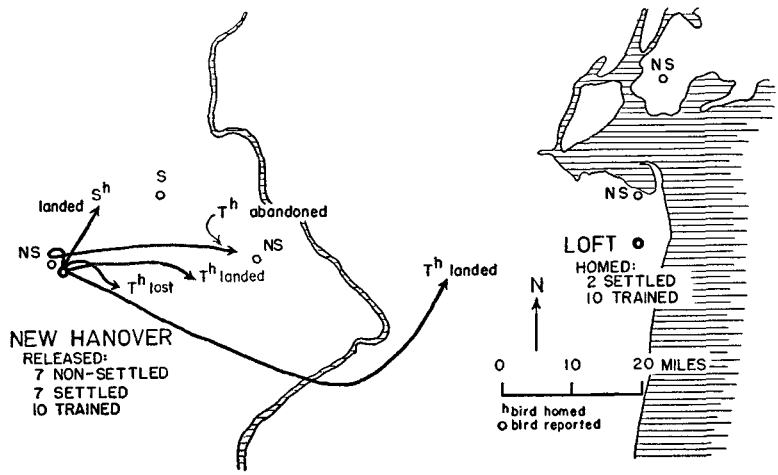


FIGURE 2. Homing flights of Fort Monmouth; singletons from New Hanover. Flights observed from plane are indicated by solid lines. NS, non-settled bird; S, settled bird; T, trained bird.

and during the afternoon. Daylight Saving Time, one hour earlier than Standard Time is referred to.

Not all birds were followed by plane, owing to limitations of time and funds. Conditions at the release points were unfavorable for extensive observation from the ground, and records of orientation were made only of birds that were followed by plane. Meteorological data are given in the Appendix.

Flights from New Hanover, Pennsylvania, 85 miles west of the loft. Figure 2. (*a*) *Trained birds.*—Ten one- and two-year-old birds were released on June 28. Nine had homed from westerly points 250–515 miles from the loft, and one from the 100-mile point, but none had ever been released at New Hanover. The four birds followed by plane flew well in the direction of the loft. The only bird that was followed more than an hour rather closely duplicated the course of one of the 1950 flocks, dipping southward into the suburbs of Philadelphia and then overcompensating to the north. This bird landed at 5:27, soon after the sun had sunk behind a cloudbank near the horizon, the rest of the sky remaining clear. Three birds homed on the day of release, at 7:45, 8:53, and "late in the evening," the exact time of the last not being known, five on the day following, and one each on the fourth and eighth days. The sun set at Fort Monmouth on June 28 at 8:27. The fastest return was made in 2 hours 46 minutes, 8 minutes slower than the faster of the two flocks in 1950, each of which homed without losses on the day of release.

(*b*) *Settled and non-settled birds.*—Seven settled and seven non-settled birds, all youngsters, were released on June 27. The only settled bird followed by plane landed 10 miles northeast of New Hanover after a flight of 19 minutes; it homed two days later. One other settled bird homed, on June 28, and another was reported on June 28, 15 miles northeast of the release point. No other settled birds were reported. Five of the non-settled birds landed immediately after being released and the others disappeared quickly behind nearby trees. Four were reported, three of them in positions indicating good orientation, the fourth 2 miles west of New Hanover.

Flights at Wurtsboro, New York, 90 miles north of the loft. Figure 3. (*a*) *Trained Birds.*—On June 29 and July 1, eleven birds were released, seven of which had homed from New Hanover, and the others of similar age and training. There was a general tendency to fly eastward. Seven birds homed, three of them on the day of release (including the two one-day birds from New Hanover that were flown), the others later. Six of the successful homers from New Hanover returned, but the seventh was reported 85 miles east of Wurtsboro.

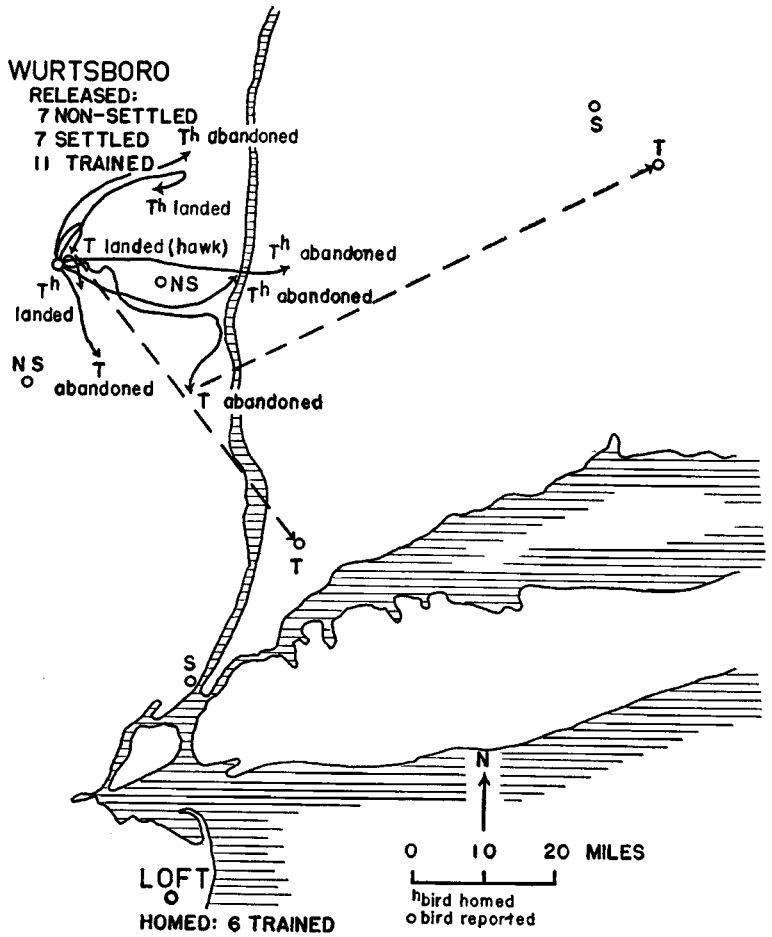


FIGURE 3. Homing flights of Fort Monmouth singletons from Wurtsboro. Broken lines join position at which followed birds were last seen to place at which they were later reported.

In 1950, two flocks of 20 birds each homed 32 birds, 19 of them on the day of release. These flocks, like the singletons, flew easterly, part of one flock reaching New Haven, Connecticut, 85 miles southeast of Wurtsboro, before heading toward the loft.

(*b*) *Settled and non-settled birds.*—Seven settled young birds were released on June 29. The only one followed by plane flew aimlessly in the vicinity for 35 minutes before being abandoned in flight. None homed, and only two were reported. Seven non-settled young birds were also released on June 29. Four landed at once and the others

disappeared behind nearby trees within 2 minutes. Two were reported, both close to Wurtsboro. None homed.

Flights at Ballston Spa, New York, 190 miles north of the loft. Figure 4. (*a*) *Trained birds.*—Ten birds were released on July 22. The five that were followed by plane took easterly courses, four of them decidedly to the northeast. Three of the four that were reported were again from the east, two of them on the seacoast. None homed. In 1950 a flock of 23 trained birds flew easterly after a period of indecisive flight; four of them homed.

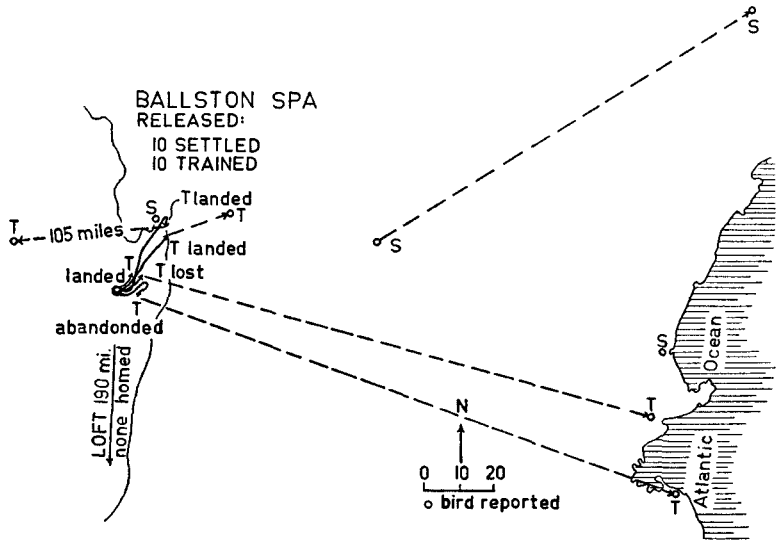


FIGURE 4. Homing flights of Fort Monmouth singletons from Ballston Spa.

(*b*) *Settled birds.*—Ten were released on July 22, four of which were followed. Three of these birds landed within two miles of the release point after flights of 6, 12, and 27 minutes, respectively, and the fourth landed four miles north after 19 minutes of aimless flight. None homed. Reports were from the east and northeast. One bird was reported twice, first 75 miles east-northeast, and then at 180 miles in approximately the same direction; another reached the seacoast. No non-settled birds were released at Ballston Spa.

Discussion of the behavior of the Fort Monmouth Birds. (*a*) *Trained birds.*—The performance of singletons (1952) was inferior to that of flocks (1950). Losses were higher and homing times slower. Kramer and von St. Paul (1950: 624) have reported similar experience. One might anticipate some confusion on the part of birds released as these were for the first time as singletons, their training having been in

flocks. It is likely, however, that all had homed part way alone since flocks normally become dispersed on flights as long as these birds had experienced. Differences in weather in 1950 and 1952 do not appear to have been significant.

The flight of the singletons as observed from the plane was more erratic than that of flocks in most instances. During the orientation period, changes in the direction of flight were frequent and abrupt; in some cases changes in altitude were conspicuous. The paths of several birds were marked with frequent deviations from side to side, though some were steady. The most erratic performance was by a bird released at New Hanover. It left the airport at once in rapid flight and flew for 28 minutes in various directions within a radius of 5 miles before landing about a mile from the release point. During this flight its altitude varied from close to the ground to 2000 feet. Despite such erratic behavior while under observation, this bird was one of the three that homed on the day of release. Its true homing flight, disregarding the part witnessed from the plane, must have been direct, for its time could not have been more than 2 hours 18 minutes, which is 20 minutes faster than the faster flock in 1950. It seems likely that the proximity of the plane contributed to this bird's initial confusion. The homing success of 13 singletons not followed by plane, or lost from sight within 2 minutes, was 62.5 per cent, as compared with 55.5 per cent for the 18 that were followed more than 2 minutes. The flocks in 1950, it should be pointed out, were all followed by plane.

Though the ten singletons released in the direction of training all homed, only three of them did so on the day of release, and two required more than two days. In 1950, 43 birds in two flocks all homed the day of release. Counterbalancing the inferior performance of the singletons as a whole is the performance of the three that did home the same day, all of them well after the usual time for pigeons to stop flying. Matthews (1953a: 254–255) reports, for example, that in a large number of flights none of his pigeons homed after sundown, and less than 1 per cent as late as an hour before sundown.

The tendency to orient in the direction of training rather than toward the loft was marked at both points off the training line. At Wurtsboro, the northeasterly tendency might have been influenced by the direction of the valley in which releases were made, but at Ballston Spa, where the same northeasterly trend was conspicuous, the terrain lacks features that would seem to influence orientation. Reports on birds that failed to home indicate that the easterly tendency persisted far beyond the release area. The singletons were all at least one year

old and had two or more seasons of training, whereas the 1950 flocks were of birds less than a year old and only one season of training. The performance of the more experienced birds, though disappointing from the angle of homing, seems to reflect their ability to respond to training—to fly in a particular compass direction. It appears that the younger birds in 1950, not having learned their lesson in directional training so well, were better able to revert to orientation toward the actual loft position. However, as pointed out below, birds without training also showed the same eastward tendency at the northern release stations.

Settled birds.—At New Hanover, the two birds that homed and the one that was reported suggest an ability to orient to the loft. None homed from the other locations. At Wurtsboro, two were reported, one in the direction of the loft and the other to the east. At Ballston Spa, two made long flights to the east, and one a short flight north. *Non-settled birds.*—None of the non-settled birds homed, but at New Hanover two of the three that were reported made flights that terminated within 25 miles of the loft, and one remained near the release point.

Although conservative opinion has been that pigeons do not home unless trained, recent work with settled birds by Matthews (1953b) and non-settled (aviary) birds by Kramer and von St. Paul (1954) has clearly shown that such birds can orient toward the loft and home to it. Thus the behavior of well-oriented untrained birds in the present account calls for no particular discussion. The similarity in the behavior of the untrained birds to the trained ones in flying an easterly course when released north of the loft, however, raises certain questions. *The experience of some of the birds may not have been as represented.* One can suspect that in the large lofts at Fort Monmouth, records of individual birds may not always be accurate. *They followed trained birds with a directional bias.* No bird was released until the preceding one was out of sight, usually after an interval of several minutes. At Wurtsboro there is little likelihood that the settled birds were influenced by the trained birds, as the latter were released two days after them. Only once, while under aerial observation, did two experimental birds meet in flight. This instance occurred when a bird was inadvertently released while the one being followed was over the airport. *Local topography influenced the direction of flight.* The earlier aerial observations revealed certain preferences for type of terrain to be flown over, ridges and wooded areas being selected rather than level ground and cleared land, but the eastward tendency could not be accounted for on this basis.

At Wurtsboro some of the birds appeared reluctant to leave the valley in which they were released, following it rather than climbing high enough to leave it while under observation. However, birds reported from Wurtsboro releases were well beyond the valley, so that it seems unlikely that local topography influenced flights for any great distance in a particular direction. *They had been genetically selected to fly eastward.* It is conceivable that the Fort Monmouth birds through generations of selection for good homing from the west could have an innate preference for flying easterly when finding themselves in a strange locality. The ability of pigeons to orient to a particular compass direction has been demonstrated by a number of investigators, and as shown by the easterly tendency of Fort Monmouth birds at Wurtsboro and Ballston Spa, orientation to a compass direction may override the more primitive ability of orienting toward the loft. However, the birds in the Middlebury flock, though of Fort Monmouth origin, have not shown an eastward tendency. *Conditions of an as yet unknown sort favored the easterly course.* Racing pigeon fanciers and investigators are familiar with instances of false orientation at places where departures have customarily been good. Similarly, it is known that at certain points pigeons rather consistently orient falsely. It is unfortunate, in trying to evaluate this possibility, that at Ballston Spa, the only place where both Middlebury and Fort Monmouth birds were released, the direction of Middlebury is roughly the same as that taken by the Fort Monmouth birds. Of these various possible explanations the last seems not the least unlikely, especially since Kramer (unpublished) has observed that in certain places both his trained and untrained birds show a tendency to orient consistently in a false direction. Another example of the tendency of birds to fly consistently in a direction that does not necessarily lead them homeward has been reported by Griffin and Goldsmith (1955), who observed that Common Terns (*Sterna hirundo*) when released inland at several places in New England take a southeasterly course regardless of the direction of their nesting area. In this case the suggestion is made that such a tendency may be correlated with the position of the coastline when the birds find themselves inland. The eastward tendency of the Fort Monmouth pigeons at northern release points, however, would seem to have no such utilitarian explanation.

BEHAVIOR OF "DETRAINED" PIGEONS

My flock at Middlebury, Vermont, received more training in 1950 from the southeast than from other directions, and when releases were made in two novel directions the birds oriented and homed

poorly (Hitchcock, 1952). At Ballston Spa, southwest of the loft, a flock split up soon after its release and the birds followed by plane flew northwest, in the direction of training. At Massena, New York, northwest of the loft, the flock also fragmented soon after release, and the birds followed flew two great circles before settling down to a steady course.

In 1952, the flock was trained in a way designed to remove any bias on the part of survivors from 1950 for flying northwest by being given 28 releases, the most distant of which was 35 miles from the loft, before the first aerial observations were made. The direction of the release point was changed each time, and the places were for the most part ones where releases had not been made previously. Between experimental flights additional releases in random directions were also made. Throughout the experimental period nesting boxes were removed from the loft and the birds given two exercise periods daily. On August 13, the date of the first aerial observation, the flock consisted of 19 birds, 16 of them veterans from 1950, and three yearlings. On October 10, 24 days after the last experimental flight, ten veterans and one yearling remained. The experimental flights are shown in Figure 5.

Flights from Worcester, Vermont, 40 miles northeast of the loft.—Eighteen birds were released in flocks of six each on August 6 at the airport, in a narrow valley flanked by hills rising 2000 to 3000 feet. Following orientation flights of 7, 7, and 4 minutes, respectively, each flock headed well toward the loft, over high ground, but each practically reversed its direction after a few miles, and only one of them could be followed to the loft. Seven birds homed the first day, six the next, and four later in the week. The one bird that failed to return was reported 20 miles east of the loft. (This bird was kept captive, but escaped in August, 1953, and returned directly to the loft.)

Flights from Ballston Spa, New York, 76 miles southeast of the loft.—On August 19, 15 birds in flocks of three, six, and six were followed. The first flock (A), composed of three birds that had homed from Ballston Spa in 1950, showed considerable indecision and remained near the airport half an hour. Two of the birds were lost 17 miles north of the release point after several minutes of circling, but the third was followed over a good course to within three miles of the loft. Two homed on the day of release, and the third on the day following. The second flock (B) left the release point immediately, flying westerly, like the flock followed in 1950. The birds were under observation for 3 hours 10 minutes, but only during the last 40 minutes did they indicate orientation toward the loft. Three homed the same day,

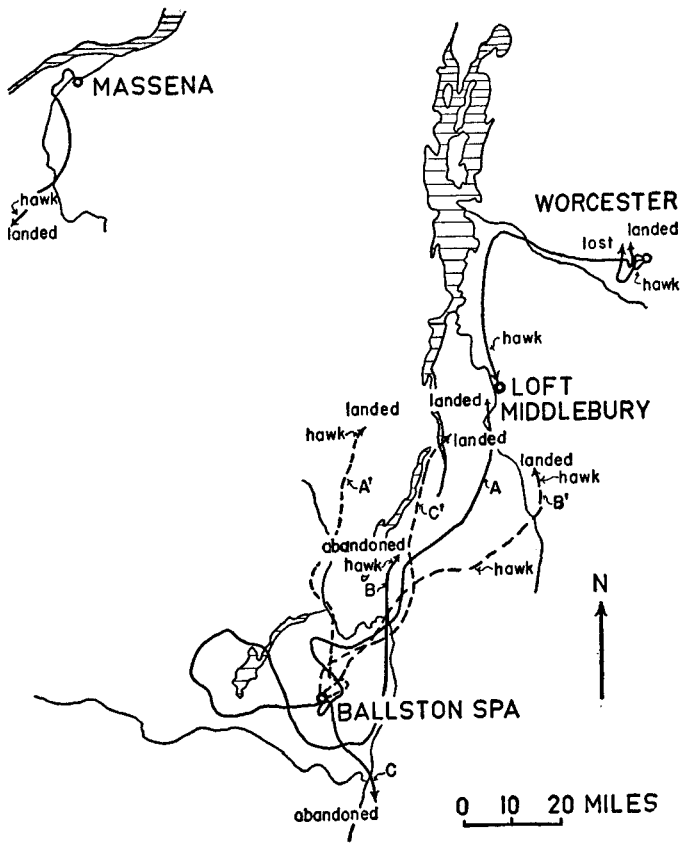


FIGURE 5. Flights of Middlebury flocks, 1952. Hawk, attack by hawk.

one much later, and one was lost. The third flock (C) was abandoned over the city of Troy after mixing with local pigeons. Five returned the next day; one was lost.

On September 9, the survivors of the August 19 flights were released again at Ballston Spa in the same groupings. All flocks (A', B', and C') made short orientation flights and headed well toward the loft. Five homed the same day, two the following day, four later, and one was lost.

Flights from Massena, New York, 106 miles northwest of the loft. Ten birds were released on September 16. Two that were released as singletons started off at once in the direction of the loft but were lost too soon for one to be sure that the true homing flight had begun. One of them homed the second day and the other, which was the only one flown in 1952 that had homed from Massena in 1950, returned

in seven days. A flock of four flew aimlessly near the airport 36 minutes, losing one member, and then headed southwest. One of this group (very possibly the one that separated from the others at the start) homed the next morning, another three weeks later, and two were lost. A second flock of four was released but not followed. Two of these birds returned the next day, another 21 days later, and one was lost. Seven out of ten birds homed in 1952, as compared with three out of ten in 1950.

Discussion of the performance of "detrained" birds.—The 1952 flights were not without a suspicion that the bias to fly in a northwesterly direction had not been completely eliminated by training. At Worcester, the one flight followed to completion was for a considerable distance after the first few well directed miles in a westerly direction, and one of the Ballston Spa flights closely duplicated the first part of the westward course flown by the 1950 flock, though with a subsequent orientation toward the loft. The flock followed at Massena showed great indecision upon release, and flew finally in a westerly direction. These improper orientations may be the result of as yet unrecognized stimuli that tend to produce false orientation at certain places, as mentioned above in the case of the Fort Monmouth birds. Other flights in the 1952 series, however, indicated a better orientation, and the homing performance was distinctly superior. Some of the improvement may, of course, be attributed to the loss of the poorer homers during 1950.

Why the three flocks at Worcester should have started off in the right direction and then practically reversed their course is not clear. In one case a hawk attack precipitated the change in direction, but in the others no such stimulus was apparent. In each instance, the birds were flying close to the ground, and it appeared as though they might have been reluctant to continue their proper course because of difficulties in the terrain ahead—a mile-wide valley and then a mass of mountains.

Though the Middlebury birds have been followed through mountainous country without significant alteration in their course because of the terrain, they have on several occasions exhibited an apparent reluctance to descend from an altitude at which they have been flying when the ground beneath them dropped away. At times they have followed a contour on a slope rather than maintaining a true course, and occasionally flocks have circled briefly upon reaching the end of a ridge they have been following. The flock that was followed to the loft from Worcester kept at a fairly constant elevation, not far above the treetops, as it flew westward, losing altitude gradually

as it entered the Champlain Valley. However, these birds, after setting their course for the loft, passed directly over Mount Philo, an isolated 600-foot peak rising from the valley, that could have been avoided by a slight deviation in course.

INITIAL ORIENTATION

In 1953, the orientation of the Middlebury birds was studied by observing the direction of their departures from the release point. This technique, which both Kramer and Matthews have employed in their field studies of orientation, has the advantages over aerial observation of being inexpensive and of eliminating the possible disturbing influence of the plane.

TABLE 1

HOMING RESULTS

Place	*Date*	*Released*		*Homed day of release*		*Homed second day*		*Homed third day*		*Homed later*		*Lost*	
		Tr.	*Sett.*	*Tr.*	*Sett.*	*Tr.*	*Sett.*	*Tr.*	*Sett.*	*Tr.*	*Sett.*	*Tr.*	*Sett.*
Bremen	July 16	13	—	0	—	0	—	0	—	6	—	7	—
Bremen	Aug. 13	—	8	—	0	—	0	—	0	—	1	—	7
Glastonbury	July 29	12	—	0	—	1	—	0	—	1	—	10	—
Glastonbury	Oct. 4	3	8	0	0	0	0	0	0	3	1	0	7
Maryland	Aug. 4	12	—	0	—	0	—	2	—	2	—	8	—
Maryland	Oct. 18	3	9	0	0	0	0	0	0	0	1	3	8
Norwich	Nov. 1	3	9	0	0	1	0	0	1	1	1	1	7
Williamstown	Nov. 22	1	10	0	0	0	3	1	1	0	2	0	4
Totals		47	44	0	0	2	3	3	2	13	6	29	33

Seven groups of releases were made from 75-foot forest observation towers and one from the ground. The direction in which the birds disappeared while viewed through 6- or 7-power fieldglasses was recorded as indicative of the bird's orientation. Both trained and settled birds were used. Most of the former were yearlings with training up to 20 miles in random directions from the loft; the rest were birds whose experience has been described above. The settled birds were all hatched in the spring and early summer of 1953. Nesting was permitted throughout the summer and the birds allowed to fly at will. The trained birds were given four, 10-mile flights in different directions early in the summer, but the settled birds' first experience at being caged was on the experimental flight. With a single exception, noted below, each bird participated in only one flight. Each bird bore a message capsule. At stations where two releases were made, only trained birds were flown on the first release.

TABLE 2

ANALYSIS OF INITIAL ORIENTATION[1]

	Bremen[3]		*Glastonbury*		*Maryland*		*Norwich*	*Summary*			
								Trained birds		*Settled birds*	
	July 16	*Aug. 13*	*July 29*	*Oct. 4*	*Aug. 4*	*Oct. 18*	*Nov. 1*	*Homed*	*Lost*	*Homed*	*Lost*
Number of pigeons	13	5	11	12	11	12	12	18	26	5	27
Mean angular deviation regardless of sign	26°	32°	54°	29°	97°	78°	80°	55°	68°	74°	57°
Standard deviation	26°	32°	80°	28°	49°	42°	44°	40°	54°	65°	44°
Probability that such scatter could have arisen by chance[2]	0.01	0.1	0.65	0.01	0.75	0.6	0.6	0.035	0.2	0.65	0.02

[1] Williamstown is not included because observation of departures was not made like the others.

[2] Values greater than 0.05 indicate scatter that cannot be differentiated from random. Calculations made according to method of Matthews, '53a, p. 244.

[3] The flock was counted in the computations as 5 birds rather than as a single unit.

The pigeons were transported to the release points by car in such a way that they could not see their surroundings, left overnight on the towers and released in the morning. The Bremen birds were kept one night and day inside a building 11 miles south before being placed on the tower. While on the towers the birds were permitted to view their surroundings. At Williamstown, where releases were made from the ground, the birds viewed their surroundings from their arrival at 10:45 A.M. until released at 12:30 and 1:30 P.M. the same day. Three of the release points were at distances greater than any of the birds had previously flown, and the others were stations that had not previously been used. Orientation, homing and meteorological data are given in Figures 6 to 9. Homing results are tabulated in Table 1 and an analysis of orientation given in Table 2.

The release at Bremen (Figure 6) on July 16 gave convincing evidence of orientation toward the loft. Eight singletons and a flock of 5 all left the tower without hesitation and disappeared im-

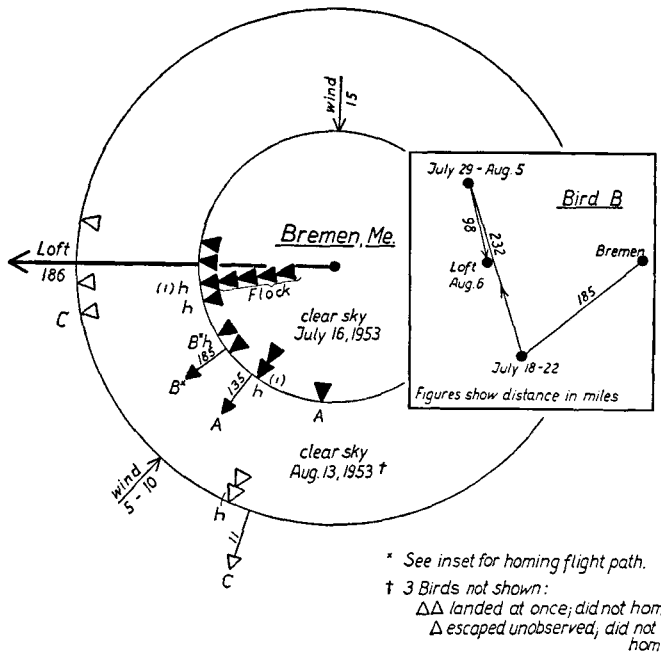
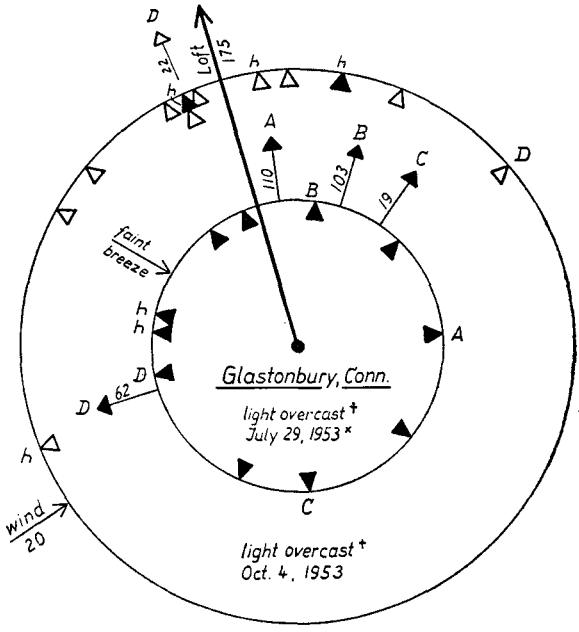


FIGURE 6. Orientation of Middlebury birds at Bremen. Pointers indicate direction in which birds disappeared. Solid pointers, trained birds; empty pointers, settled birds. Outward arrows, direction and distance in miles at which birds were reported. Inward arrows, direction and velocity (miles per hour) of wind. h, bird homed; capital letters, birds reported.

mediately in straight, well-directed flight. Seven settled birds released there later oriented more slowly and less accurately. At Glastonbury (Figure 7) the departures of the first group were in random directions. Possibly noise from a radio in the tower room where they spent the night affected their behavior, for the later group that was kept on a lower level of the tower had good orientation. Within a few hundred feet of the Glastonbury tower, a radio relay station operates 24 hours daily. The signals are concentrated into a narrow beam to one side of the observation tower, but some birds undoubtedly flew through it. The signals have a frequency of about 4,000 megacycles, and about one-half watt is used to direct the beam. These signals do not appear to have influenced the orientation of the birds.

At Maryland (Figure 8) the first group oriented randomly. The second group also showed random orientation, but there was a bunching at about 60° from the loft direction. Departures in both cases were slow. At Norwich (Figure 9) departures were also in random



×▲ *escaped unobserved; did not home.*
† *intermittent sunshine*

FIGURE 7. Orientation of Middlebury birds at Glastonbury. For explanation, see Figure 6.

directions and after long orientation flights. Bird B, whose homing flight from Bremen is shown in Figure 6, was released at Norwich and returned on the 46th day, this time without progress reports. At Williamstown (Figure 9) the birds were released in groups of 5 and 6. Each started its flight eastward, apparently to take advantage of sloping ground to gain altitude quickly, and then turned north and disappeared without wavering in its course. Because trees blocked sight of the flocks at about a quarter of a mile, the performance of these birds is not included in the analysis of orientation in Table 2.

DISCUSSION: INITIAL ORIENTATION OF MIDDLEBURY BIRDS

The generally poor performance in orientation, and homing as well, was disappointing in view of the decidedly superior performances reported by both Kramer and Matthews. Whether the Middlebury birds were genetically poorer than those of the other investigators or whether they had to perform under greater handicaps of management, weather, and topography is not clear. All were from a flock built up over a period of five years through selection of birds able to home. They were picked by chance for various releases. The

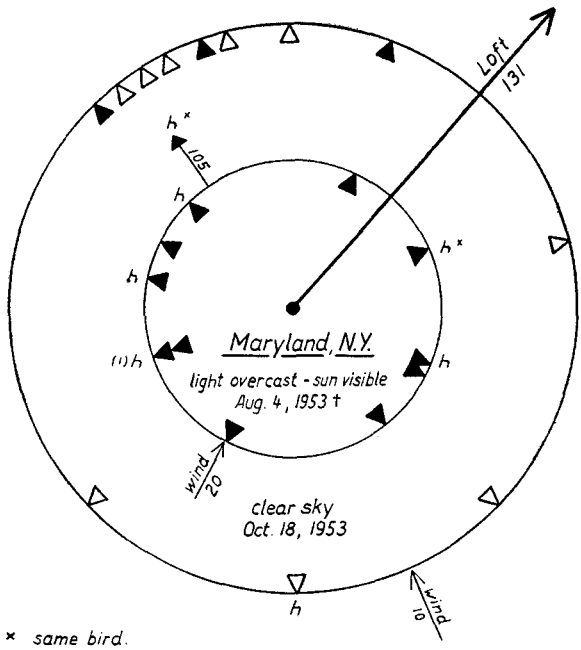


FIGURE 8. Orientation of Middlebury birds at Maryland. For explanation, see Figure 6.

fact that orientation was not random at Bremen (July 16), Glastonbury (October 4), and probably at Williamstown suggests that unrecognized factors interfered with the effective utilization of the birds' abilities on other occasions. As might have been expected, those of the *trained birds* that homed showed a significant orientation toward the loft, whereas those that failed to home showed random orientation (Table 2). It is not particularly surprising, especially in view of the small numbers of birds concerned, that among the *settled birds* the orientation of those that homed was not as good as that of those that failed to home, for homing success is influenced largely by experience whereas orientation is innate (see Matthews, 1953b).

The best substantiated theory of orientation in homing birds is the sun navigation theory of Matthews (1953a). The theory postulates a very accurate time sense and the bird's ability to compare the sun's altitude and position in azimuth where the bird is with similar conditions at the loft. It has received support from Matthews' observation that birds orient poorly in overcast weather. These observations are also in accord with Kramer's (1952) discovery that caged birds orient poorly when the sun cannot be localized. They suggest that the birds utilize in orientation wave lengths that are visible to man.

In this connection the Williamstown performance is of interest,

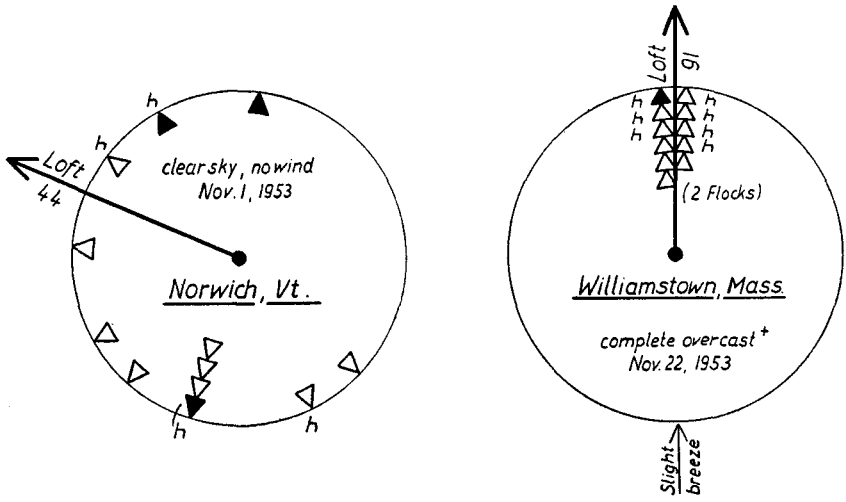


FIGURE 9. (left) Orientation of Middlebury birds at Norwich. (right) Orientation of Middlebury birds at Williamstown. For explanation, see Figure 6.

for here the birds apparently oriented promptly and three of them subsequently homed under a heavy overcast through which the sun's position could not be distinguished. Bees can orient when the sun's position is obscured by overcast, and von Frisch (1953) has recently reported that this ability is lost if light from the ultraviolet end of the spectrum (3000–4000 Å) is prevented from reaching them. Experimentation should soon show whether the pigeon can utilize similar wave lengths in orienting itself.

Though pigeons are reluctant to fly at night, they can be trained to do so. Correspondence with pigeon fanciers in Hawaii indicates that pigeons are regularly raced at night there. The birds are released one hour after sundown and race time expires one hour before sunrise. The course customarily flown, about 95 miles from Puunene on the island of Maui to Honolulu, includes two stretches of about 18 and 25 miles across water. Night fliers cover this course in times comparable with those of day birds. The greatest distance over which pigeons are raced is 140 miles, from Upolu Point, Hawaii, to Honolulu, with an over-water stretch of about 20 miles. Returns on this course have not been good. In the Hawaiian Islands, where homing might more understandably depend upon the recognition of land masses than on a less limited continental area, one may question whether navigation is involved. The night-flying Hawaiian pigeons and the performance of the Middlebury birds at Williamstown both suggest, however, that sun navigation may not be the only way in which pigeons can orient themselves.

SUMMARY

Airplane following of homing pigeons released singly in unfamiliar territory showed greater indecision and poorer homing than when flock releases, previously reported, were made. Experienced birds trained from the west, homed best from the west but tended to fly eastward when released at two places north of the loft. An eastward tendency was also exhibited by birds that had not received directional training. These results are discussed.

Airplane followings of flocks of homing pigeons trained in a way designed to produce no bias to fly in a particular compass direction are described. Orientation of trained and untrained birds as indicated by the direction in which they disappeared upon release and observed from the ground, is recorded from five stations. Statistical treatment indicates that in more than half of the releases orientation was of a random sort. These results are discussed. The orientation of birds under total overcast is discussed in relation to Matthews' theory of sun navigation.

APPENDIX

Weather Conditions for Flights in 1952

June 27—sky 40 per cent filled with cumulus clouds; visibility 10 miles; wind 5 miles per hour from south.

June 28—partly cloudy, but sun's position apparent; visibility 5 miles; no wind.

June 29—in morning overcast but sun's position apparent; improvement in afternoon to 80 per cent cloud-free sky; visibility good; no wind.

July 1—scattered cumulus clouds; visibility unlimited; no wind.

July 22—scattered cumulus clouds; visibility unlimited; wind 15 miles per hour from northwest.

August 13—sky 40 per cent filled with cumulus clouds; visibility unlimited; wind 15 miles per hour from northwest.

August 19—sky almost cloudless; visibility unlimited; weak wind from west.

September 9—sky almost cloudless; light haze; wind 5 miles per hour from southwest.

September 16—sky 60 per cent filled with cumulus clouds; visibility unlimited; wind 20–25 miles per hour from west.

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