THE EFFECT OF PHASE SHIFTS IN THE DAY-NIGHT CYCLE ON PIGEON HOMING AT DISTANCES OF LESS THAN ONE MILE[1]

LOUIS C. GRAUE
Bowling Green State University, Bowling Green, Ohio

Schmidt-Koenig (1958, 1961) has reset the physiological "chronometers" of homing pigeons by shifting the day-night cycle. He then transported these birds along with controls away from their loft and released them. Pigeons subjected to a day beginning and ending 6 hours early, usually gave mean departure directions on release roughly 90 degrees counterclockwise to that of control groups. A 6-hour-late day gave rise to a 90 degree clockwise shift in headings. Significant results have been obtained at distances of from 5.5 to 100 miles from the loft.

These findings can be interpreted according to Kramer's (1953) idea of a "map and compass" process in which orientation is considered to consist of two steps; to establish the position of displacement and to define compass directions. The sun azimuth can serve as the compass, but as yet, no acceptable suggestion has been made as to how the position of displacement is determined.

Schmidt-Koenig (1958) has claimed that the results of his clock-resetting experiments provide evidence for an orientation method independent of landmarks, even at short distances. The shortest distance reported in his experiments was 5.5 miles. According to our observations, pigeons rarely travel more than one mile from home if they are provided with food and water at the loft, and given freedom to fly. Even those transported for release from distant points, couldn't be expected to fly over a given point frequently enough to gain a great deal of familiarity with the landmarks in that vicinity. The experiments reported below were designed to investigate the effect of shifting the day-night cycle on pigeon homing, from points visited by the birds nearly every day in the course of their natural activities. In this case, there is no doubt about the degree of familiarity with the landmarks in the vicinity of the release points.

METHODS

Homing pigeons selected for their homing ability and usually given continuous freedom to fly, served as the subjects from which experimental and control groups

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were chosen. Birds to be shifted were placed in a light-proof cubical cage measuring four feet on each dimension. In this cage a time clock switched a 20-watt fluorescent tube on and off. Birds designated as backward (forward) shifted, had the light on and off 6 hours later (earlier) than sunrise and sunset, respectively. Birds denoted as controls were placed in a similar size pen which was opaquely enclosed except for a wire floor which admitted natural daylight.

At least four days prior to an experimental release, birds were selected from the free flying colony and confined to the cages described. The birds were removed from these pens immediately prior to their transportation to the release point. No effort was made to keep them covered during the experiment and releases were usually underway within 10 min after removal from the pens.

Releases involving forward (backward) shifted birds were carried out over a time interval with 9 AM (3 PM) as its center, in order to have the sun altitude

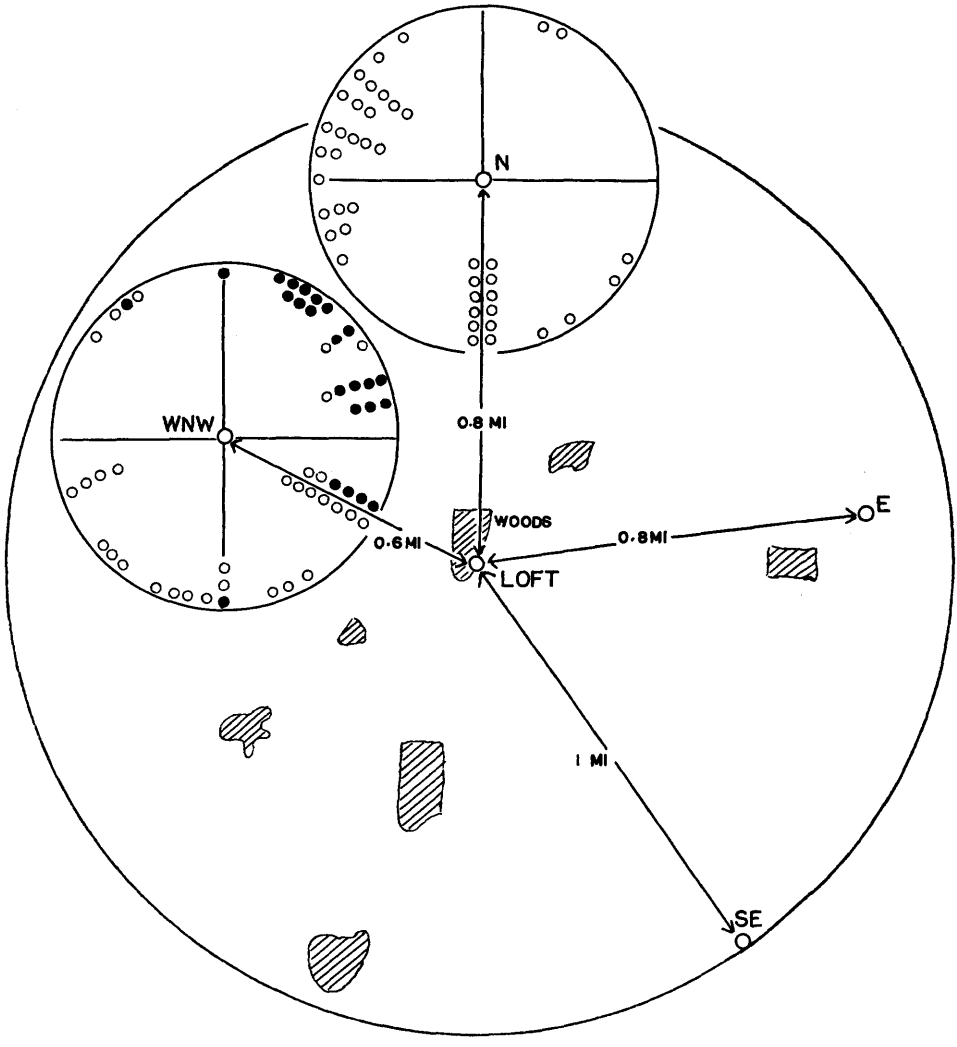

FIGURE 1. Location of release points and vanishing bearings. Small open (solid) circles represent vanishing bearings of backward (forward) shifted pigeons. Shaded regions represent wooded areas present within a one mile radius of the loft.

approximately correct for the shifted day. We used a small number of birds on successive days, rather than a large number on one day. This was necessary because of the above sun altitude consideration, and also because some control birds would continue to fly around the area of the loft, which could then affect headings of succeeding releases.

The birds were released individually, usually alternating shifted and control birds. They were followed through 7 x 50 binoculars until they reached the loft area, or vanished from sight at 1.5 to 2 miles. Bearings were recorded at 20 sec, 40 sec, and at vanishing. As soon as one bird vanished or reached the loft, the next bird was released. Occasionally a stray pigeon, or one released earlier would join with a bird being watched. When this happened, we discarded the data for that bird.

RESULTS

Four release points were used and are plotted in the figure as 0.8 mile N, 0.8 mile E, 1 mile SE, and 0.6 mile WNW. The following groups all flew directly to the loft and their headings are not pictured in the figure: Controls at all points, all shifted birds at the E and SE points, and the forward shifted birds at the N point. The vanishing bearings of the backward shifted birds at the N point are plotted on the circle drawn about it and clearly indicate a shift to the right. In the circle about the WNW point, the vanishing bearings of the backward shifted birds are plotted as open circles, and show a clear shift to the right. The headings of the forward shifted birds at the WNW point are given by the solid circles, and show a shift to the left.

The shaded regions which are drawn approximately to scale in the figure, represent the wooded areas occuring within a one mile radius of the loft. The remainder of the very nearly flat countryside, consists mostly of cultivated fields.

As long as the loft is screened from the release point by the woods, the results indicate that the headings of the birds can be shifted in the predicated direction by shifting the day-night cycle, even at points within their home territory. However, when a direct view of the loft is available, the shifting has no effect. At the N point the forward shifted birds started out toward the east, but as soon as the loft came within view they abruptly turned toward it and flew home.

No difference was noted in the take-off direction of controls from release points with the loft in direct view, or when the loft was not directly visible.

SIGNIFICANCE

The results of shifting experiments provide evidence that the sun azimuth compass is one basic constituent of the initial orientation mechanism of homing pigeons. The bird must also have a mechanism which determines at least the direction it has been transported. It is clear that for long distances, no direct visual reference to the home territory could be involved.

It is then natural to raise the following question. At what point is the mechanism which locates the direction of the loft replaced by direct visual reference to the home territory? The shifting technique applied at decreasing distances would appear to be useful in finding the answer. We would not expect to be able to shift headings once the point was reached where the bird had to rely on visual reference to the home territory.

The results of the experiments presented above indicate that our question is not so easily answered. The bird evidently uses the sight of the loft to guide its homeward flight, but it does not use other adjacent landmarks, such as the woods, in the same way. If it did, then we could not have shifted the headings as in those cases where the loft was screened by the woods.

These releases were conducted at points which the birds flew over every day in their natural activity, and since the distance involved was so very short, it would not seem reasonable to believe that the long distance orientation mechanism

could have been involved in their behavior. It would appear more reasonable to suggest an explanation involving landmarks. It is possible that the pigeon determined its position by triangulation from two or more familiar landmarks, and then set its course with the sun compass. Even though the compass is not necessary in this situation, perhaps this is the natural way for the pigeon to fly when a direct view of its goal is not available.

A reviewer of this paper offered the following explanation: "Released near a familiar landmark and not in direct view of the loft, a bird might remember from previous flights the sun's position at the respective time of day, and also the approximate angle at which it would have to fly to the sun's azimuth, in order to get home. This would lead a control bird toward the loft, but a shifted one, having the wrong time, would make an error in take-off direction which was observed."

Further experiments are necessary to determine whether or not these conjectures are true. Schmidt-Koenig's results are also open to similar landmark interpretations. In the case of his long distance releases, we would have to consider whether the birds had participated in previous flights near the release point.

LITERATURE CITED

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