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HOMING-PIGEON VANISHING BEARINGS AT MAGNETIC ANOMALIES ARE NOT ALTERED BY BAR MAGNETS

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Keeton (1971, 1972) has shown that pigeons released under overcast skies are often disoriented by bar magnets. When the sun is visible, magnets deflect the average vanishing bearing slightly to the left. Essentially similar results can be obtained with paired coils around the pigeon's head – a dramatic effect under overcast (Walcott & Green, 1974; Visalberghi & Alleva, 1979) and a small deflexion under sun (Walcott, 1977). Releasing pigeons at magnetic anomalies where the earth's magnetic field is distorted has a substantial effect even under sunny conditions (Graue, 1965; Talkington, 1967; Frei & Wagner, 1976; Wagner, 1976; Walcott, 1978). Since the scatter of pigeon vanishing bearings is significantly correlated with the strength of the anomaly (Walcott, 1978), it seems probable that the distortion of the earth's magnetic field is causing the effect and not some secondary characteristic of the release site.

Keeton, Larkin & Windsor (1974) have shown that pigeon vanishing bearings are correlated with natural variations in the earth's magnetic fields even when the sun was visible. Attaching magnets to the pigeons' backs eliminated this effect (Larkin & Keeton, 1976). This result might imply that the stronger field of the magnet is swamping the receptor and preventing pigeons from detecting the small changes in the normal earth's field. If this were the case, it could be that magnets would also abolish the disorientation that occurs at magnetic anomalies. This paper presents the results of releasing pigeons carrying bar magnets at two magnetic anomalies.

Experienced, adult pigeons were taken to either of two magnetic anomalies where they had never been before. One group of birds was equipped with small magnets about 1 in. long and $\frac{3}{16}$ in. in diam. which produced a field strength of about 1 Gauss at the pigeon's head. Control birds carried brass rods of the same size. Each pigeon also had a radio transmitter (Cochran, 1967). Pigeons were released singly under sunny skies and the direction to the pigeon was recorded every minute for 15 minutes or until the pigeon vanished from radio range. The distribution of 15 min and vanishing bearings for each group were compared with the Watson U^2 test.

As Fig. 1 makes clear, each group of birds showed poor orientation at both magnetic anomalies. Birds with magnets showed no significantly better or worse orientation than the birds with brass weights. There was no difference in either homing success or homing time for the two groups.

These results are interesting for several reasons. First, they clearly contrast with Larkin & Keeton's (1976) results; magnets did not eliminate the effect of magnetic

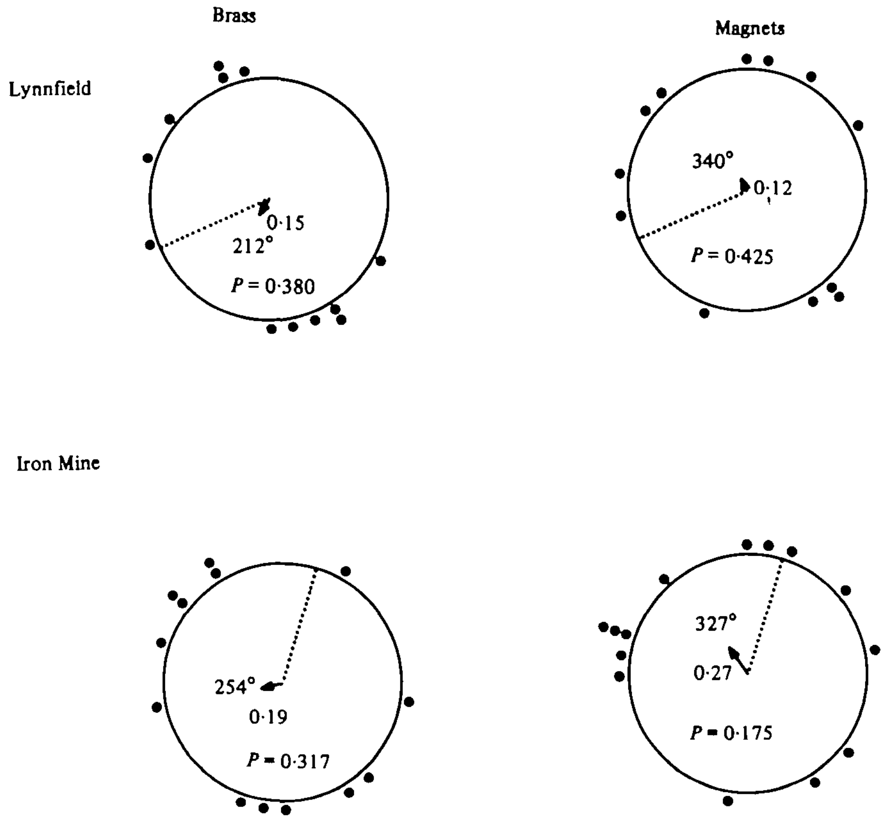

Fig. 1. The bearings of pigeons released at two magnetic anomalies. Each dot around the circle represents the direction from the release point to a pigeon 15 minutes after release or when it had vanished from radio range. Magnetic north is at the top of the circle and the dotted line indicated the direction to the home loft. The arrow in the centre is the mean vector; its length and direction are indicated. The probability that the observed distribution of bearings arose by chance is given by *P*. The Watson U^2 test shows that there is no significant difference between the bearings of the birds with magnets and birds carrying brass weights.

anomalies in the same way that they did the natural variations in the earth's field. Secondly, although the variations in magnetic field strength at the magnetic anomalies we used (1000–2000 γ) are an order of magnitude stronger than the natural fluctuations in the earth's magnetic field (10–100 γ) they are still much weaker than the field of the bar magnet (100000–150000 γ). This must mean that pigeons are somehow able to detect the distorted field of the anomaly even in the presence of the stronger constant field of the magnet. This conclusion is hard to reconcile with the observation that these same bar magnets would seriously disorient pigeons released under overcast skies. Could it be that pigeons, as Keeton, Larkin & Windsor (1974) suggest, use magnetic fields in either of two ways: as an auxiliary compass system under overcast skies or as part of the mysterious 'map' under both sun and overcast? Could it also be that for some reason bar magnets and paired coils disturb the magnetic compass but not the magnetic component of 'map'? Perhaps the magnetic compass depends upon the total, steady magnetic field of the earth, whereas the 'map' in some way uses changes in the field sensed, perhaps, as the pigeon flies. Possibly the compass system is like a tonic receptor and the 'map' like a phasic one. Wiltschko's (1972) report that for the magnetic compass of the European robin, the magnetic field strength must be within 10% of the natural earth's field, coupled with the disorientation of homing pigeons caused by magnets and coils under overcast all argue that the intensity of the magnetic field is important for compass orientation.

Unfortunately there is no direct evidence that the 'map' is in any way based on magnetic cues. Yet the pigeon's behaviour at magnetic anomalies certainly suggests that the disturbance in the earth's magnetic field reduced the accuracy of the pigeon's orientation. Furthermore this disorientation occurs under sunny conditions and with experienced, adult pigeons. Normally, experienced birds show only a small angular deflexion under sun in response to the much stronger magnetic fields of a bar magnet or paired coils.

Yet if one accepts the idea that the 'map' has a magnetic component that is for some reason immune to the effects of bar magnets or paired coils, how can one interpret Keeton, Larkin & Windsor's (1974) results? Or the reports of Schreiber & Rossi (1978) and Schreiber & Rossi (1976) that homing speed is correlated with sun spots? At present there seems to be no answer to these questions. The only thing that seems clear is that the orientation of pigeons released at magnetic anomalies is different from their behaviour when they are released at magnetically calm sites.

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