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STUDY OF HOMING PIGEONS IN BRAZIL: SOME PRELIMINARY RESULTS

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1- ABSTRACT

Preliminary conclusions from an analysis of brazilian pigeon racing results and a few scientific observations of vanishing bearings are described, and indicate the ability of pigeons to home quite well under some rather unfavourable conditions, namely with the sun not too far from the zenith and under total overcast in relatively weakly inclined magnetic fields, as well as in cases where the inclination of the magnetic field actually reverses during the flight home. Homing also occurs in regions where the apparent diurnal motion of the sun's azimuth reverses during the year, the midday sun being to the north in june and to the south in december. Furthermore homing has taken place almost right across the so called south atlantic anomaly, at which the principal component of the Earth's magnetic field has an absolute minimum, providing a situation in which the gradient of total intensity is zero in all directions.

2- INTRODUCTION

A number of global geographical and geomagnetic features present in Brazil can be usefully employed for homing research. It is surprising that thus far practically all research in the literature has been centered in a narrow band of latitudes in temperate regions of the Northern Hemisphere (1) where environmental conditions are remarkably stable and propitious for homing with the aid

of two of the best known and characterized cues namely those derived from the sun's azimuth and from the geomagnetic field. In parts of the world where these cues are weaker, and sometimes outright absent, it might be expected that novel mechanisms, which might or might not be part of the system used by pigeons elsewhere, can be more easily discovered, proven and studied. Alternatively the absence of any such new mechanisms might be established if the birds were observed to be disoriented or unable to home under such circumstances.

3- GENERAL CONSIDERATIONS

3.1- Geographical features

Two special characteristics of the apparent motion of the brazilian sun on the celestial sphere are considered here:

- a) Passage near the zenith observed around midday, twice a year, from any point between the tropics. In this case the sun provides no, or weak, azimuth information, a situaion akin to total overcast.

It might be wondered therefore if the same difficulties observed under overcast carry over when pigeons are released with the sun in the zenith, particularly in relation to magnetic field effects.

- b) Reversal in the direction of the daily motion of the sun's azimuth, which occurs more markedly near the equator, separating the part of the year during which the midday sun culminates in the north (around june) from the part of the year in which the opposite is true (around december).

In this case, it might be wondered if pigeons might not be confused by this "reversal". In june, for a normally standing or level flying pigeon, the sun's azimuth

evolves by moving to the left as the day progresses; in december it moves to the right. It might be hard for pigeons to tell north from south (i.e. right from left) by reference to the sun at those times of the year in which the reversal is being smoothly carried out, with the midday sun culminating near the zenith and providing little azimuth information at that time. In the morning the sun's azimuth remains approximately constant in the east, and in the afternoon in the west. Since the sun's motion is essentially vertical, discrimination of north from south under these circumstances requires memory of "right and left" from previous experience.

3.2- Geomagnetic features

In conjunction with the above, the earth's magnetic field also presents two characteristics in Brazil that are relevant in what follows:

- a) Near the magnetic equator the geomagnetic field is nearly horizontal.

Considering the importance that has been attributed to the inclination of the ambient magnetic field (Walcott and Green, 1974; Wiltschko and Wiltschko, 1972), it might be speculated that near the magnetic equator the orientation of pigeons should be hampered, especially under conditions of total overcast, or when the sun is near the zenith, i.e. when the sun compass is inoperative.

- b) There is a broad absolute minimum in the modulus of the steady component of the geomagnetic field (the so called south atlantic anomaly) in the southern part of the country.

Although not so widely documented, conjectures have been made concerning the possibility that the modulus of the magnetic field contributes to some extent in the

make-up of the "map" (Gould, 1980). If this were true, the invariance of the modulus of the geomagnetic field near the absolute minimum should imply some difficulty in navigation. Even if the inclination of the geomagnetic field around the minimum is $\sim 24^{\circ}$, which is considerably different from zero, meaning that the magnetic compass might still be perfectly operational, it might be thought that the map around the minimum is somewhat harder to read than elsewhere, and that this might cause some navigational difficulties.

4- RESULTS

Preliminary results of some relevance to the above general considerations have been obtained through a few observations of vanishing bearings and by analysing results of pigeons races in Brazil.

4.1- Vanishing bearings

Several releases principally from the east northeast, which is a most convenient direction logistically, were carried out at several distances up to almost 100 km, from São José dos Campos, SP. Experienced, mostly one year old pigeons were used. They had been flock-trained from several directions up to 10-15 km, and had been free to fly around the loft on one or two occasions almost every day. The pigeons and the loft were in all ways possible normal, of the sort to be used as controls. On one occasion a release was carried out under conditions of total overcast, at a new location, but at a distance of only 12 km. The vanishing bearings observed on this occasion are shown as dots in Fig. 1. The crosses on the same figure refer to pigeons released from 45 km under sunny skies, coincidentally from very nearly the same direction. Several other releases were carried out

under partial cloud cover and with sun. The purpose of these releases was mainly to establish if observation of vanishing bearings through binoculars is a technique which yields significant results in this part of the world under normal, control type, circumstances. As can be seen in Fig. 1 this is clearly the case, for both of the experimental conditions in question; the vanishing bearings are well bunched and significantly homeward oriented. This was the case in practically all the releases, including one carried out between local 11:40 and 14:50 h in february with the sun coming to within 7° of the zenith.

In the region of these releases the inclination of the geomagnetic field is about 25° , which might well be more than enough for the magnetic compass to be working perfectly. Proximity to the so called south atlantic anomaly implies a gradient of about 0.3 nT/km in the modulus of the geomagnetic field, about one order of magnitude less than in the northern temperate zone, but which might still conceivably be detectable. The above tests yield thus rather general results, indicating that no dramatic effects occur when not too close yet to the limiting conditions described in section 3.

4.2- Pigeon races

Much the same sort of conclusion can be drawn by inspecting the results of pigeon races everywhere in Brazil. Unfortunately pigeon racing in this region is not so widespread and does not have the tradition of other parts of the world, so that it is very difficult, if not impossible, to carry out a significant statistical analysis correlating for example meteorological or magnetic storm factors to racing speed or losses, as done

summarize, however, some undeniable facts. The lower case letters refer to locations from which pigeons successfully homed to lofts indicated by the corresponding upper case letter. It is clear that pigeons in this part of the world are well able to home over distances (and also at speeds) similar to those of their european or american colleagues, in spite of the possible complications mentioned in section 3.

Successful racing lofts have been established rather near the equator (São Luiz do Maranhão (L) 2°S , and Recife (K) 8°S) where the reversal in the direction of motion of the sun's azimuth is quite marked.

Pigeons are also able to home across the magnetic equator (Teresina, Piauí to Belo Horizonte, Minas Gerais magnetic 5°N to 18.5°S - 1800 km; Paraiso do Norte, Goiás to Goiânia, Goiás, and to Campinas, São Paulo, magnetic 1.5°N to 10°S - 720 km, and to 21.5°S - 1450 km - respectively; and Imperatriz, Maranhão to Goiânia, Goiás magnetic 9.5°N to 10°S - 1240 km). It is not known whether or not total overcast conditions prevailed at any of these crossings, but it seems unlikely. These races all took place towards the end of the racing season, which for the cities involved means end of august - mid september. The midday sun thus was to be found reasonably clearly in the north, not too near the zenith. These performances are nonetheless fairly impressive, 7 of 28 pigeons making it from Imperatriz to Goiânia, for example, the first ones in 3 days, and again indicate the absence of dramatic effects due to approximating the difficulties described in section 3.

Finally, the Curitiba to Blumenau (B in Fig. 2) race has taken pigeons probably very nearly right across the

so called south atlantic anomaly, with no major signs of difficulty encountered.

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5- CONCLUSION

Although little work has been carried out so far, there is some indication that pigeons are able to home quite well in the general sort of environment described in section 3. In particular they are able to cross the magnetic equator. Evidence is lacking, however, that this could be done when the magnetic field is most important, i.e. in the absence of sun azimuth information. Unfortunately the pigeon racing sport is not very widespread in Brazil, and reliable and complete data of racing results are to be found only for recent years, a fact which prevents a statistically significant study of several correlations from being made. The simple technique involving binocular observation of vanishing bearings has been shown to be applicable at least in some parts of this region. Pigeons relatively not too far from the magnetic equator and quite near the south atlantic anomaly seem well oriented, even under total overcast and when released with the sun relatively near the zenith. However these data are not sufficient to conclude that pigeons did not use any of the cues we were trying to eliminate or mask. Besides increasing sample size for better statistical significance, it will be necessary to carry out experiments under artificially altered conditions and in more nearly ideal locations and seasons, right on the magnetic equator and right in the middle of the south atlantic anomaly. Such experiments are planned and have partially begun.

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Fig. 1- Vanishing bearings of pigeons releases under total overcast (dots) from a distance of 12 km from the loft (24 May 1980), and with full visibility of the sun (crosses) from 45 km (31 May 1980). North is up and the direction of the loft is at 255° in both cases. For the dots and the crosses we have $n=9$, $r=0.82$, and $n=18$, $r=0.94$ respectively, both homeward oriented at $p < 0.0001$, (V test).

Fig. 2- Map showing release sites (lower case letters) and destinations (corresponding upper case letters) of pigeon races in the past ten years. Arrows have been placed approximately half way between home and furtherest release site, and at magnetic equator straight-line crossings. The slightly irregular ellipse between the states of Paraná and Santa Catarina in the south of the country is the locus of equal total geomagnetic field (principal steady component) at 24000 nT, about 40 nT above the absolute minimum. Details of these races are given in Table I. The numbers associated with the lines roughly paralel to the magnetic equator indicate the inclination of the geomagnetic field.

Table 1 -Some details of the races shown in Fig. 2.

We are aware of the conditioning experiments of Schmidt-Koenig (1963) and of the work with fish by Hasler and Schwassmann (1960), among others. These were however mostly sporadic expeditions and not continued and systematic, locally based research. Some work on bees has been carried out in the West Indies (New et al., 1961).

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TABLE I

CODE	LOCATION OF LOFT	RELEASE SITE	KM	DIRN	TIME OF YEAR
A	Porto Alegre, RS	São Paulo, SP	780	NE	Oct.
		Florianópolis, SC	360	NE	
		Brasília, DF	1680	NNE	
		Corumbá, MT	1500	NNE	
		Erechim, RS	270	NNW	
		Uruguaiana, RS	540	W	
		Alegrete, RS	420	W	
		Cachoeira, RS	170	W	
		Rio Pardo, RS	110	W	
		Osório, RS	260	SW	
B	Blumenau, SC	Curitiba, PR	180	N	Aug.
		São Miguel, SC	440	W	Nov.
		Chapecô, SC	350	W	Oct.
		Ercal do Oeste, SC	240	W	Oct.-Nov.
		Curitibanos, SC	155	W	Sept.-Oct.
		Pouso Redondo, SC	95	W	Sept.
C	Santos, SP	Brasília, DF	1000	NNW	Aug.
		Ipameri, GO	718	NNW	Jun.
		Araguary, MG	611	NNW	Jun.
		Rincão, SP	318	NW	Aug.
D	São Paulo, SP	Cuiabá, MT	1400	NW	Sept.-Oct.
		Brasília, DF	950	NNW	Aug.-Sept.
		Goiânia, GO	800	NNW	Aug.-Sept.
		Cristalina, GO	800	NNW	Aug.
		Ipameri, GO	667	NNW	Aug.
		Catalão, GO	600	NNW	Aug.
		Araguari, MG	560	NNW	Jul.-Aug.
		Uberlândia, MG	537	NNW	Jul.
		Barretos, SP	382	NNW	Jul
		Bebedouro, SP	340	NNW	Jul
		Barrinha, SP	300	NNW	Jun - Jul
		Ribeirão Preto, SP	300	NNW	Jun - Sept
		Rincão, SP	262	NNW	May - Jun
		Limeira, SP	120	NW	May - Aug
E	Campinas, SP	Paraíso Norte, GO	1450	NNW	Aug
		Goiânia, GO	720	NNW	Jun
		Pires do Rio, GO	540	NNW	Jun
		Araguari, MG	500	NNW	Jun
		Uberaba, MG	350	NNW	May
		Igarapava, SP	318	NNW	May + Oct
		Jardinópolis, SP	200	NNW	May
		Belo Horizonte, MG	490	NE	
	S.José Campos, SP	Ubaporanga, MG	550	NE	Aug - Sept
		Fervedouro, MG	450	NE	Jul - Aug
		Leopoldina, MG	370	ENE	Jul
		Matias Barbosa, MG	300	ENE	Jun - Jul
		Valença, RJ	240	ENE	Jun
		Cruzeiro, SP	110	ENE	Jun
		Lorena, SP	90	ENE	May

CODE	LOCATION OF LOFT	RELEASE SITE	KM	DIRN	TIME OF YEAR
G	Rio de Janeiro, RJ	Vitória, ES	450	NE	Oct
		Cach. Itapemirim, ES	300	NE	Sept
		Campos, RJ	230	ENE	Jun
		Macaé, RJ	160	ENE	Aug
		Sorocaba, SP	430	W	Jul
		Guarulhos, SP	350	W	Jul
		Jacareí, SP	280	W	Jun
		Pindamonhangaba, SP	210	W	Jun
		B. Mansa, RJ	100	WNW	
H	Belo Horizonte, MG	Teresina, PI	1800	N	
		Petrolina, PE	1500	NNE	
		Juazeiro, BA	1500	NNE	
		Feira Santana, BA	950	NNE	
		Itaberaba, BA	920	NNE	
		Jacu, BA	700	NNE	
		Monte Azul, MG	540	N	
I	Gov. Valadares, MG	Medina, MG	290	N	Jul
J	Goiânia, GO	Imperatriz, MA	1240	N	Aug
		Paraíso Norte, GO	720	N	Jun - Aug
		Gurupi, GO	600	N	Jun - Aug
		Alvorada, GO	500	N	Jun - Jul
		Porangatu, GO	380	N	Jun - Jul
		Uruaçu, GO	240	N	Jun
		Rialma, GO	170	NNW	Jun
		São Francisco, GO	90	NNW	Apr - May
		Brasília, DF	170	NE	May
		Caldas Novas, GO	120	ESE	Jul
		Parauna, GO	160	WSW	May
K	Recife, PE	Junco Seridó, RN	250	NW	Oct
		Campina Grande, PB	150	NW	Sept
		Nazaré da Mata, PE	50	NW	Sept
		Ouricuri, PE	600	W	Nov
		Salgueiro, PE	470	W	Oct
		Serra Talhada, PE	375	W	Oct
		Caruaru, PE	120	W	Sept - Nov
		Arapiraca, AL	280	SW	Oct
		União Palmares, AL	180	SW	Oct
		Palmares, PE	100	SW	Oct
L	São Luiz, Ma	Teresina, PI	320	SE	
		Caxias, MA	280	SSE	
		Codó, MA	200	SSE	
		Coroatã, MA	160	S	
		Catanhede, MA	110	S	
		Rosário, MA	35	S

Fig. 1 - R. Ranvaud

Fig. 2- R. Ranvaud