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The magnetic compass of domestic chickens

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In a recent paper, we showed that domestic chickens can be trained to search for a social stimulus in specific magnetic directions. Chickens can hardly fly and have only small home ranges, hence their having a functional magnetic compass may seem rather surprising. Yet considering the natural habitat of their ancestors and their lifestyle until recently, the advantages of a magnetic compass become evident.

Keywords: Domestic chicken, avian magnetic compass, non-migrants, navigation within home range, domestication

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In a recent paper,[1] we reported that young domestic chickens, *Gallus gallus domesticus*, can use their magnetic compass to find a hidden social stimulus from day 8 after hatching onward. This finding raises the question: Why do birds like chickens have a magnetic compass at all?

When the avian magnetic compass was first discovered in European Robins, *Erithacus rubecula*,[2] its biological significance seemed evident: robins are migrants and use their magnetic compass to orient their migratory flights. The same was true for several other avian species that were shown to have a magnetic compass (for a list, see 3). The first avian non-migrant that was demonstrated to have a magnetic compass was the homing pigeon, *Columba livia* f. *domestica*,[4,5] but here, too, one might argue that these birds home over long distances and hence might need a magnetic compass. But for what reason do domestic chickens, birds that are barely able to fly, using their wings mainly to fly up perches or trees for security at night, and that have only a rather small home range, need a magnetic compass? Here, at the first glimpse, the biological significance is not obvious.

The magnetic compass of chickens was demonstrated in directional training experiments with young chickens that had been imprinted on a red table tennis ball and searched for this ball—their "mother"—when it was hidden.[6] The subsequent analysis showed that the chicks' magnetic compass worked in the same way as the magnetic compass of robins:[7] it is an inclination compass, has a flexible biological window, depends on short-wavelength light, and is based on radical pair processes with cryptochrome 1a as the most probable receptor molecule.[8] This type of magnetic compass has been found in all bird species analyzed so far, regardless whether they are migrants or non-migrants like the homing pigeon or the Zebra Finch, *Taeniopygia guttata*[9]—it seems to be a mechanism common to all birds. Chickens and robins belong to different avian lineages—the Galloanseres and the Neoaves—that separated 95 million years ago in the Late Cretaceous;[10] the finding that they have the same type of magnetic compass suggests that this compass was probably developed by the common ancestor of modern birds in the Mesozoic.

Hence chickens have probably inherited their magnetic compass from their ancestors. However, it would be surprising if such a complex mechanism remained intact and functional over such a long time without being maintained by some selective pressure. Today, chickens are domestic animals, living in the care

of man. They descended from the Red Jungle Fowl, *Gallus gallus*,[11,12] and their wild ancestors roamed in the dense jungle of Southeast Asia.[13] In this environment, the magnetic compass would be very helpful: because of the closed canopy and the thick foliage, the birds could not orient with the help of the sun compass. There are numerous landmarks, but tree trunks and bushes are all quite similar, and they change with time, sometimes rapidly because of storms. Using the magnetic compass to keep track of their movements, or using the compass together with some prominent landmarks, as proposed by the concept of the mosaic map,[14,15] would be a useful, efficient strategy.

Humans began to domesticate chickens some 8000 years ago.[12,16] But at first, their environment did not change so much. Until about 50 to 100 years ago, most chickens were running around freely in farm yards and adjacent fields,[17] and here, it would have been still advantageous to have a compass available. Only very recently chickens have been confined to small cages with hardly any space to move. Still, 2 different modern strains of chickens, both bred for egg laying, have been shown to have retained their ability to orient with the magnetic compass.[18]

The magnetic compass found in chickens and other non-migrants suggests that it is an important mechanism for orientation within the home range. It may have developed to optimize the daily movements between the nest, food sources, water, to save energy, and minimize the chance of predation—here, an efficient navigational system represents a great advantage. A magnetic compass is also demonstrated in a number of animals from other groups (see 19 for review), and these are mainly not migratory. When some birds later began to migrate, they could call on their already existing magnetic compass to orient their long flights.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

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