Robustness of flight leadership relations in pigeons

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Animal Behaviour

Collective animal movements produce spectacular natural phenomena that arise from simple local interactions among group members. Flocks of homing pigeons, Columba livia, provide a useful model for the study of collective motion and decision making. During homing flights, flock members are forced to resolve potentially divergent navigational preferences in order to stay together and benefit from flying in a group. Recent work has demonstrated that some individuals consistently contribute more to the movement decisions of the flock than others do, thereby generating stable hierarchical leader–follower networks. Yet, what attributes of a flying pigeon reliably predict leadership remains an open question. We examined the flexibility of an individual’s hierarchical leadership rank (i.e., its ordinal position when flock members are ranked according to the average time differences with which they lead or follow others) as a function of changes in its navigational knowledge. We manipulated already established hierarchical networks in three different flocks, by providing certain individuals with additional homing experience. We found that such training did not consistently lead to an increase in birds’ leadership ranks, and that, in general, the nature of leader–follower interactions between trained and untrained birds remained unaffected. Thus, leadership hierarchies in pigeon flocks appear resistant to changes in the navigational knowledge of a subset of their members, at least when these changes are relatively small. We discuss the implications of our results in light of the potential benefits of structural stability in decision-making networks.

A flock of birds circling over its roosting site is a magnificent aerial display. Theoretical work suggests that these highly synchronized and coordinated movements arise from simple interaction rules, without the need for centralized organization (Vicsék et al. 1995; Couzin et al. 2002; Vicsék & Zafeiris 2012). None the less, we are only just beginning to understand how rules implemented in models relate to those applied by animals. Progress in digital image processing and high temporal resolution tracking has allowed the inference of interaction rules in bird and fish species (e.g., Ballerini et al. 2008; Lukeman et al. 2010; Herbert-Read et al. 2011; Katz et al. 2011). Furthermore, in line with researchers’ increasing interest in the role of interindividual differences in shaping interactions (Conradt et al. 2009; Nakayama et al. 2012a), it has been found that flocks of homing pigeons, Columba livia, are hierarchically organized, with individuals contributing with different weights to the movement decisions of the flock (Nagy et al. 2010). Such hierarchical networks consist of transitive leader–follower relationships in which birds consistently copy the directional choices of individuals above them in the hierarchy, while being copied by those lower in rank. Little is known about what attributes of a flying pigeon can reliably predict leadership in flocks, although it has been suggested that leadership may be related to individual navigational efficiency (Nagy et al. 2010).

Empirical studies have identified a variety of traits (e.g., age, experience, social rank and motivation; Rebs 2000; King et al. 2008; McComb et al. 2011; Nakayama et al. 2012b) that can modify an individual’s propensity to initiate a movement or activity change. Along similar lines, a model by Conradt et al. (2009) suggests that group movements are directed by those specific individuals for whom reaching the goal is most crucial. Several empirical studies support the findings of these models. For example, fish that are deprived of food are more likely to take front positions in shoals than those that are satiated (Krause et al. 1992), and, and lactating female zebra, Equus burchelli, initiate movements more frequently than those without dependent foals (Fischhoff et al. 2007). Furthermore, consistent leadership in group movements might be supported by the enhanced knowledge of certain individuals. In several species, including golden shiners, Notemigonus crysoleucas, bottlenose...