Democracy in animal groups: A political science perspective

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Conradt and Roper [1] investigate 'democratic' decisions among animals. Some red deer herds move when 62% or more of the animals stand up. Honey bees reach consensus on nest sites in coordinated dances. Voting behaviour includes body postures, movements and vocalizations. Why does democracy give animals an evolutionary advantage? Conradt and Roper suggest it is because democracy produces less extreme decisions than despotism. Drawing on the jury theorem of the 18th century French thinker the Marquis de Condorcet, I suggest a further explanation: Democracy is good at pooling the information of different individuals.

Conradt and Roper's model addresses group decisions on starting or stopping some synchronous activity. Individuals vote on the basis of their activity budgets. Condorcet's model can represent group decisions under uncertainty whose payoffs (costs and benefits) depend on some feature of the environment: whether a predator is nearby, whether food exists at some site, whether some travel route is optimal. Individuals vote on the basis of noisy, but partially reliable signals: Some may have noticed a predator or food source (a positive signal), others not (a negative signal). Condorcet proved the following [2,3]. Suppose each signal is correct – matches the relevant feature – with a probability p above 1/2 but below 1, and different signals are mutually independent. Then the probability that a majority among n signals (binomially distributed) is correct equals

$$\sum_{k>n/2} \binom{n}{k} p^k(1-p)^{n-k}.$$

As illustrated in Figure 1, this probability exceeds p (except for small even n, where majority ties are frequent) and approaches 1 as n increases, by the law of large numbers. A democratic decision among n individuals is more likely to be correct than a despotic decision by one individual.

Condorcet's model has testable implications for animal group decisions. Suppose payoffs of correct and incorrect decisions are symmetrical for different equally probable states of the environment [4]. The best nest site might be in one location or another, other things equal. Here majority voting is optimal: It maximizes the probability of a correct decision. Suppose payoffs are asymmetrical or one state is more probable than another [4,5]. When a group finds a modest food source in a harsh environment, false positive decisions (searching further when no better food source exists) are more costly than false negative ones (not searching although a better one exists). Here special majority voting is optimal: Requiring strong support for abandoning a food source makes false positives less probable. When there may be predators, false negative decisions (not moving when a predator is present) are more costly than false positive ones (moving although none is present). Here sub-majority voting is optimal: Allowing a few warning signals to alert the group makes false negatives less probable. Similarly, special majority voting is used in criminal trials to protect the innocent, and sub-majority voting in decisions on considering legislative initiatives to avoid overlooking valid initiatives.

Democracy still outperforms despotism under several generalizations of Condorcet's model, including differentially reliable signals among individuals [3,6], certain dependencies between individual signals [3,7], non-binary decisions [8], and some but not all cases of strategic voting [9].

Democratic information pooling has been noted, but not formally explained, in relation to honey bees' choices of nest sites [10], where Conradt and Roper's activity synchronization model does not apply. I suggest the importance of Condorcet's model for explaining the use of democratic methods in animal group decisions under uncertainty.

References

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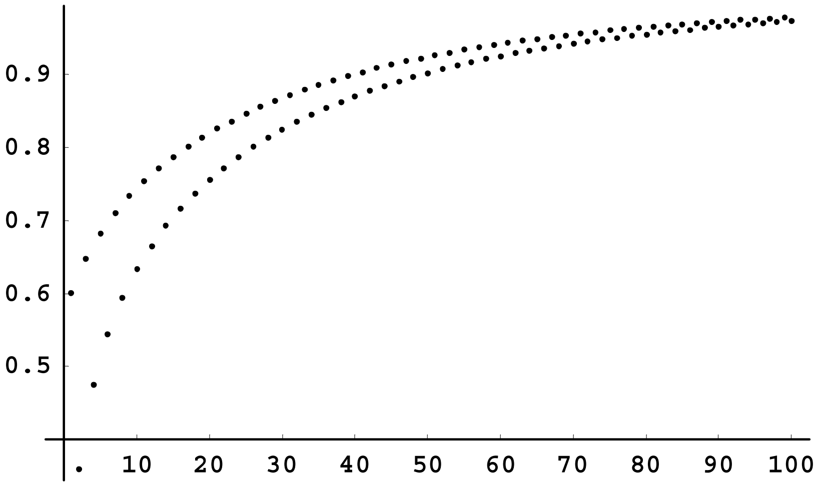

Figure 1: Probability of a correct majority decision (*y*-axis) for groups of size $n = 1$ to 100 (*x*-axis), where each individual signal has a reliability $p = 0.6$. A correct majority decision is slightly more probable for odd *n* (top curve) than for even *n* (bottom curve) because majority ties are impossible for odd *n* but possible for even *n*.

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