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Buffon's Needling Ants | Numbers

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The classic probability experiment known as Buffon's needle produces a statistical estimate of the value of pi, the ratio of a circle's circumference to its diameter.

The experiment consists of randomly dropping a needle over and over again onto a wooden floor made up of parallel planks. If the needle's length is no greater than the width of the boards, the probability of the needle meeting or crossing a seam between boards is twice the needle's length, *l*, divided by the plank width, *d*, times pi: 2*l*/*d*p.

The idea of estimating pi by randomly casting a needle onto an infinite plane ruled with parallel lines was first proposed by the naturalist and mathematician Georges Louis Leclerc Comte de Buffon (1707�1788). He himself apparently tried to measure pi by throwing sticklike loaves of French bread over his shoulder onto a tiled floor and counting the number of times the loaves fell across the lines between the tiles.

In 1901, the Italian mathematician Mario Lazzarini claimed to have tossed a needle 3,408 times and obtained a value of pi equal to 355/113, or 3.1415929, which differs from the exact value by less than 0.0000003. How he managed to ensure truly random needle casting and got his remarkably accurate pi estimate isn't clear, though mathematicians have recently argued that cheating must have been involved.

Subsequent experiments by other investigators typically produced less accurate values of pi. In recent years, computer simulations have taken over�with results modulated by quirks of the random number generators involved in the computations.

Now it appears that a certain ant species uses a Buffon's needle algorithm to measure the size of potential nest sites. Eamonn B. Mallon and Nigel R. Franks of the Centre for Mathematical Biology at the University of Bath in England report their findings in the April 22 *Proceedings of the Royal Society of London B*.

Ants of the species *Leptothorax albipennis* inhabit small, flat crevices in rocks. A colony typically consists of a single queen, her brood, and 50 to 100 workers. When a nest happens to get destroyed, the colony sends out scouts to assess potential new nest sites.

Given a choice, a colony's preference is for a nest of a certain "standard" size (related to the number of ants in the colony), which suggests that these ants can measure areas. How do they do it?

Mallon and Franks collected ants from areas near the Dorset coast of England and raised them in the laboratory. They then transferred colonies to large, square Petri dishes and offered the colonies choices of various cavity habitats, made from pairs of microscope slides with cardboard walls spanning the narrow gap between glass floor and glass ceiling.

"We used such microscope slide nests with nest cavities of different sizes, shapes, and configurations in order to examine preferences," the researchers note.

Experiments involving individually marked workers demonstrated that a scout generally spends about 2 minutes scurrying within any particular candidate cavity. Moreover, scouts typically end up making two visits to an acceptable nest site before recruiting followers.

When a scout initially explores a potential nest site, it lays down a pheromone-laced track. On its second visit, it follows a different track, repeatedly crossing its original path.

Mallon and Franks argue that a scout can obtain an estimate of the potential nest's area by detecting the number of intersections between the first and second set of tracks. In effect, an ant scout applies a variant of Buffon's needle theorem: The estimated area, A, of a flat surface is inversely proportional to the number of intersections, N, between two sets of lines, of total lengths S and L, randomly scattered across the surface, or $A = 2SL/pN$.

"There is evidence that individual scouts recognize and respond to intersections between their second visit path and their first visit path," the researchers say. "Scouts briefly but significantly slowed down during their second visit when they intersected their first visit path."

Additional observations bolster the plausibility of the claim that these ants assess nest size using a Buffon's needle algorithm. Moreover, the method is relatively insensitive to the shape of the area to be assessed and to the exact pattern of the tracks (as long as the tracks are not concentrated within just one region). In addition, it will work in complete darkness.

"Our findings, that individual ants can make accurate assessments of nest areas based on a rule of thumb, show in a unique way how animals use robust algorithms to make well-informed quantitative decisions," Mallon and Franks conclude. The results demonstrate how information gathering by individual workers can contribute to crucial collective decisions.