# Optimized by Evolution, Ants Don't Have Traffic Jams

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While observing ants traveling on a trail, scientists observed that, unlike in vehicular traffic, the average velocity of ant traffic remains the same in spite of increasing density. Image credit: Alexander John, et al.

(PhysOrg.com) -- As highway traffic increases, you'd probably expect a traffic jam, where vehicles slow down due to the high density. While traffic jams are a common occurrence on our highways, high density traffic has completely different effects for ants traveling on trails. As a new study has found, ants don't have traffic jams. Rather, as ant traffic density increases, the traffic maintains the same average velocity as at low densities.

A team of researchers from institutions in Germany, India, and Japan discovered this surprising result while observing the ant species Leptogenys processionalis travel down linear trails. Like many other ant species, these ants form trails with their pheromones that remain stable for hours or even days, making the trails analogous to vehicular highways.

“Our study clearly demonstrates that ant traffic is very different from vehicular traffic, in spite of superficial similarities,” Andreas Schadschneider, of the University of Köln and the University of Bonn in Germany, told *PhysOrg.com*. “It also raises a fundamental question: how do the ants achieve practically ‘free-flow’ up to such high densities; our experiment demonstrates what happens and we also make a theoretical model of what might be responsible for this behavior.”

To observe the ants in their natural setting, the researchers set up video cameras at sections of 10 different one-way trails that had no intersections or routes that branched off. Surprisingly, the scientists never observed individual ants speeding up to overtake another ant in front; the ants followed each other in single file. This behavior, of course, contrasts with vehicular highway traffic, as well as most other known traffic forms.

Most significantly, the scientists found that, unlike vehicular traffic, the average velocity of ant traffic remains the same in spite of increasing density. Consequently, the greater the density, the greater the flux, so that more ants travel down the trail segment in a given amount of time. In contrast, vehicles on a highway tend to slow down when the traffic density increases, eventually resulting in a traffic jam. Along the same lines, the researchers noted that most types of high-density traffic exhibit mutual blocking, in which a vehicle is prevented from moving by neighboring vehicles and also contributes to the blocking of those vehicles. However, the researchers did not observe mutual blocking in the ant trails.

As the researchers suggested, perhaps evolution has optimized ant traffic flow, since ants are known to have highly developed social behaviors. In their study, the scientists observed that ants tend to form platoons in which they move at almost identical velocities, allowing them to travel “bumper-to-bumper” while maintaining their velocity. At higher densities, platoons merge to form longer platoons. But because their head-distance remains the same, traffic still maintains its same velocity even as density increases. This behavior is very different from highway traffic, in which vehicles close together tend to slow down.

“For the ants, an efficient transport system is essential for the survival of a colony,” Schadschneider said. “Food sources are usually not in the immediate neighborhood of the nest and so the transport has to be well organized. Therefore it is not surprising that evolution has optimized the behavior of the ants (or all social insects). On the other hand, human transportation systems still reflect a certain desire for freedom and individuality. In contrast to ant traffic, what dominates in human traffic are two things: selfish (non-cooperative) behavior, and large body weight of vehicles where any contact between the vehicles would be costly (for the cars as well as for the riders' lives). Ants, on the other hand, do not mind body contacts which become unavoidable at high densities."

As he explained, understanding ant behavior will require further study: "Now entomologists have to connect this behavior of ants to their 'thinking and sensing' process. Our work opens up the possibility of collaborations between entomologists, physicists, mathematical modelers and traffic scientists."

While this study shows that the collective marching of ant traffic seems to be very different from vehicular traffic, the scientists suggest that ant traffic might be more analogous to human pedestrian traffic. They plan to explore this analogy in the future, and they predict that their results could have applications in swarm intelligence, ant-based computer algorithms, and traffic engineering.

"To our knowledge, so far applications in swarm intelligence mainly draw from the analogy with the formation of ant trail networks," Schadschneider said. "Our study was focused on a different aspect, namely the usage of an already existing trail. Combining both approaches could open promising perspectives for future applications, e.g. in optimization problems.

"From a traffic engineering point of view, the results give some indication on how to improve the situation on our highways," he added. "As the example of the ant trail shows, non-egoistic behavior could improve the situation for almost everybody. However, this will be difficult to achieve since, very much in contrast to the ants, drivers and their cars are very different. Another interesting point is the relevance of communication between the vehicles. On ant trails this is achieved mostly on a chemical basis. In the future, our cars might be connected electronically and transmit e.g. information about velocity changes immediately. This would allow the driver to react much quicker to a new situation."

More information: John, Alexander; Schadschneider, Andreas; Chowdhury, Debashish; and Nishinari, Katsuhiro. "Trafficlike collective movement of ants on trails: absence of jammed phase." *Physical Review Letters*, 102, 108001 (2009).