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This is a highway to hell: A theoretical study of wildlife-vehicle collisions by simulation

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Wildlife-vehicle collisions (WVC) are estimated to kill up to 200 million birds and 30 million mammals annually in Europe¹, and are a significant driver of losses for many already endangered amphibian and reptile species^{2,3}.

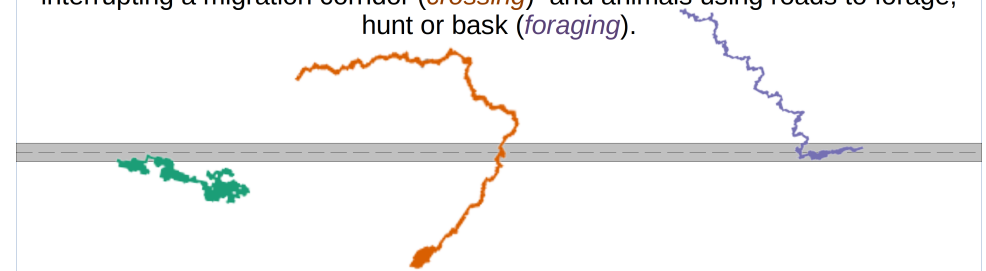
While extensively studied through empirical data, WVC are seldom approached from a purely theoretical perspective. They fall under the frameworks of both Ideal Gas Models and Traffic Flow Theory models, two models of varying spatial scales and suitability to the problem at hand. Both differ in their predictions, notably about the role of animal speed and traffic volume in WVC, and they both contradict existing evidence of the impact of vehicle speed on reported collision numbers.

None of these models account for known animal behaviours in the presence of roads (road avoidance, scavenging, hunting, basking) or the repartition of suitable habitats around roads.

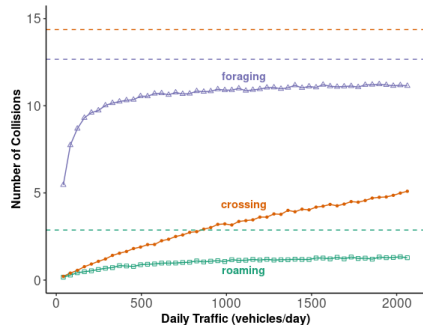
Simulation work therefore appears essential to clear the air and help disentangle pure physics from species-specific reactions to oncoming vehicles, driver behaviour and existing correlations between studied factors in empirical-based modelling.

We developed a simulation of collisions using unidirectional and uniform movement for vehicles and biased-correlated random walks to simulate animals.

Different scenarios of behaviours were investigated: animals roaming without behavioural responses to the presence of vehicles (thereafter: *roaming*), roads interrupting a migration corridor (*crossing*) and animals using roads to forage, hunt or bask (*foraging*).



Each scenario is run 1000 times, computing the number of collisions for 15 animals over a biologically significant activity period of 12 hours.



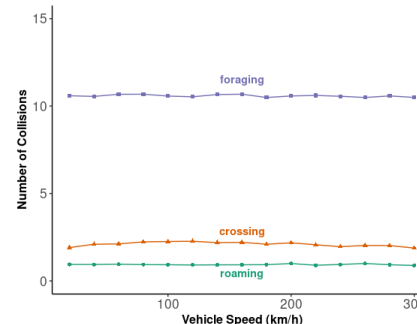
Effect of daily traffic volume on collision numbers for three scenarios of behaviour. Each point is the mean over 1000 runs of the simulation. Dashed lines for each scenario represent the actual number of animals crossing the road at least once during the simulation.

Traffic volume has non linear effects and collision number reaches a plateau for *roaming* and *foraging* that is below the number of animal getting to the road (dashed lines).

→ differs from model predictions: Ideal Gas Model predicts linear relations while Traffic Flow Theory models asymptotically approach 100% of crossing animals.

Vehicle speed has no effect on collision number.

→ Coherent with both Ideal Gas Models and Traffic Flow Theory models, but not with empirical studies.
 → Most likely, factors such as reduced reaction time for drivers and animals, and the correlation between speed limits and road traffic & width are to blame.



Effect of vehicle speed on collision numbers. Each point is the mean over 1000 runs of the simulation.

- Highly frequented roads are often less deadly than intermediate ones, an effect solely attributed to the repelling action of high traffic flows on wildlife⁴ → as evidenced here, highly frequented road are not always expected to have more casualties.

- Vehicle speed in itself is not a driver of local WVC numbers, but has a well-documented effect on roadkill that is most likely dependant on behavioural reactions to oncoming vehicles and is therefore species-dependant⁵.