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Individual based modelling of the effects of cannibalism on genetic resistance to Bt in the fall armyworm

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The fall armyworm (*Spodoptera frugiperda*) is a pest insect which has the propensity to destroy a wide variety of common crops. It ranges over Eastern and Central North America and, since 2016, has been invasive in Africa resulting in significant economic damage. The fall armyworm is susceptible to Bt derived insecticides, making Bt modified crops a viable method for controlling this species. However, there is evidence to suggest that there is a small subpopulation of the fall armyworm which is resistant to Bt. This population remains relatively small in the wild due to the cost of resistance, which is partially mediated by the aggressive cannibalism exhibited by the larvae, since resistant larvae grow at a slower rate. Thus it may be possible to control the rise of resistance to Bt in a fall armyworm population via the creation of refuges for the nonresistant larvae who will in turn cannibalize the resistant larvae.

Here we use an individual base modelling (IBM) approach to model an infestation of fall armyworms, which models every individual's entire life cycle including cannibalistic encounters and the effects of its Bt resistance genotype. First, we explore the best underlying mathematical models to describe the individual insects in the IBM. Then we examine the problem of controlling the accumulation of resistance to Bt via adjustments to the size and spacial layout of the refuge while limiting the damage to the effected crops.

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