BLURBS FOR LOCUST MODEL

LEK*

18th July 2011

1 State of the Art

A recent general review of models for aggregation based on attraction and repulsion is provided by (Schellinck and White, 2011). Purely theoretical models for swarming include integro-differential equations (Mogilner and Edelstein-Keshet, 1999). Application of such ideas to flying locust swarms include Edelstein-Keshet et al. (1998) and Topaz et al. (2008).

As far as marching locusts, there have been a number of studies in which data collected in the laboratory and theoretical models have been combined. Most models concerned with alignment of locusts moving in a group (Romanczuk et al., 2009; Buhl et al., 2006; Yates et al., 2009) as well as proportion of locusts moving at a given time (Bazazi et al., 2008, 2011) depending on treatments such as diet and denervation. The motivation in many of these models is to explore the transition between a disordered and a coherent marching group capable of great destructive force. Romanczuk et al. (2009) formulated an abstract model of collective motion, with repulsion and attraction that was then modified by Bazazi et al. (2011) for locusts. The authors describe an individual-based model with locust in 2 states (stopped, moving) with stochastic transitions. They consider that locusts sense others in a spatial range and that this leads to an escape-dominated response with a parameter χ that reflects the strength of social interactions. They take a repulsive range of 2 cm and assume that the strength of the repulsion is χ_r=10cm/s^2. They write a Langevin equation for the speed and orientation of each locust. The main output of the model is proportion of individuals moving and mean group speed as a function of the group density. (The mean group speed varies sigmoidally (over the range 0-7 cm/sec) with density in the range of 0-100 locusts /m^2.

2 Biology

Patchy clumps of vegetation that lead to crowing of locusts also enhance their levels of activity and induce them to become gregarious (Despland et al., 2000). (This was often quantified as a correlation between the fractal dimension of the vegetation and the locust behaviour (Collett et al., 1998). Contact or sight of locusts coming from behind enhances the tendency of a locust to move

*

(Bazazi et al., 2008). A transition from solitarious to gregarious type can be evoked by rubbing the hind leg of a locust for 5 sec every 60 sec during a period of 4 hrs Simpson et al. (2001).

3 Parameters

A recent paper by Bazazi et al (Bazazi et al., 2011) gives many parameters that are directly useful in our model

- Speed of locust when it is alone varies from 2 to 6 cm/sec depending on diet.
- Speed of locust in a group varies in a tighter range of 4-6 cm/sec.
- critical density for the onset of collective motion is given in the range of 50 to 80 locusts /m^2
- According to Bazazi et al (Bazazi et al., 2011) and (Buhl et al., 2006), the sensing range of a locust is 14 cm, and the repulsion range is 4 cm, which coincides roughly with the body size of the locust.

References

S. Bazazi, J. Buhl, J.J. Hale, M.L. Anstey, G.A. Sword, S.J. Simpson, and I.D. Couzin. Collective motion and cannibalism in locust migratory bands. *Current Biology*, 18(10):735–739, 2008.

S. Bazazi, P. Romanczuk, S. Thomas, L. Schimansky-Geier, J.J. Hale, G.A. Miller, G.A. Sword, S.J. Simpson, and I.D. Couzin. Nutritional state and collective motion: from individuals to mass migration. *Proceedings of the Royal Society B: Biological Sciences*, 278(1704):356, 2011.

J. Buhl, DJT Sumpter, ID Couzin, JJ Hale, E. Despland, ER Miller, and SJ Simpson. From disorder to order in marching locusts. *Science*, 312(5778):1402, 2006.

M. Collett, E. Despland, S.J. Simpson, and D.C. Krakauer. Spatial scales of desert locust gregarization. *Proceedings of the National Academy of Sciences*, 95(22):13052, 1998.

E. Despland, M. Collett, and SJ Simpson. Small-scale processes in desert locust swarm formation: how vegetation patterns influence gregarization. *Oikos*, 88(3):652–662, 2000.

L. Edelstein-Keshet, J. Watmough, and D. Grunbaum. Do travelling band solutions describe cohesive swarms? an investigation for migratory locusts. *Journal of mathematical biology*, 36(6): 515–549, 1998.

A. Mogilner and L. Edelstein-Keshet. A non-local model for a swarm. *Journal of Mathematical Biology*, 38(6):534–570, 1999.

P. Romanczuk, I.D. Couzin, and L. Schimansky-Geier. Collective motion due to individual escape and pursuit response. *Physical Review Letters*, 102(1):10602, 2009.

J. Schellinck and T. White. A review of attraction and repulsion models of aggregation: Methods, findings and a discussion of model validation. *Ecological Modelling*, 2011.

SJ Simpson, E. Despland, BF Hägele, and T. Dodgson. Gregarious behavior in desert locusts is evoked by touching their back legs. *Proceedings of the National Academy of Sciences*, 98(7): 3895, 2001.

C.M. Topaz, A.J. Bernoff, S. Logan, and W. Toolson. A model for rolling swarms of locusts. *The European Physical Journal-Special Topics*, 157(1):93–109, 2008.

C.A. Yates, R. Erban, C. Escudero, I.D. Couzin, J. Buhl, I.G. Kevrekidis, P.K. Maini, and D.J.T. Sumpter. Inherent noise can facilitate coherence in collective swarm motion. *Proceedings of the National Academy of Sciences*, 106(14):5464, 2009.