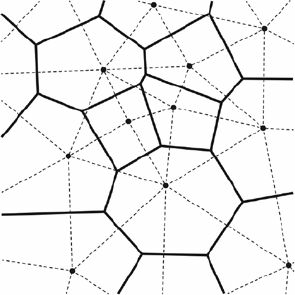
[**Fol­low­ing the Herd**](part0004.html#ch83)

Birds, fish, and many mam­mals, like an­te­lope and buf­falo, group to­gether into “swarms” that we call flocks, shoals, or herds. Their self-or­ga­niz­ing be­hav­ior is often un­can­nily pre­cise. When huge flocks of star­lings fly through the air at the end of the day we might ask how they or­ga­nize them­selves to cre­ate a group that seems to move as one great co­or­di­nated body. Some­times the move­ment fol­lows sim­ple de­fen­sive rules. If you are in a shoal of fish that might be under at­tack from preda­tory sharks then it is a good idea to keep away from the pe­riph­ery. This pro­duces a con­tin­u­ous churn­ing of the shoal as mem­bers try to avoid being on the vul­ner­a­ble edge. Con­versely, some fly­ing in­sects want to be on the out­side of the swarm in order to be the first to at­tract the at­ten­tion of po­ten­tial mates. Some birds and fish stay near their im­me­di­ate neigh­bors; they move away from those who get too close, but are at­tracted back to the group if they stray too far from it. Oth­ers only pay at­ten­tion to their seven or eight near­est neigh­bors and align them­selves with their speed and di­rec­tion of move­ment.

All these strate­gies can lead to large-scale or­derly swarms and the im­pres­sive pat­terns of birds and fish that we see in Na­ture. Other more com­pli­cated strate­gies can be imag­ined for human in­ter­ac­tions. For ex­am­ple, some­one might move around at a large cock­tail party aim­ing to get as close to one per­son as they can while get­ting as far away as pos­si­ble from some­one else. If lots of peo­ple are doing that at the same party then the re­sult is not easy to pre­dict!

An­other, math­e­mat­i­cally in­ter­est­ing strat­egy is that adopted by a herd of vul­ner­a­ble wilde­beest or an­te­lope when a sin­gle preda­tor, like a lion, ap­pears on their hori­zon. Each an­i­mal will move so as to en­sure that there is at least one other an­i­mal along the line of sight be­tween it­self and the preda­tor. When the preda­tor is sta­tion­ary this will re­sult in the herd adopt­ing a par­tic­u­lar pat­tern that math­e­mati­cians call a “Voronoi tes­sel­la­tion.” To con­struct it for a col­lec­tion of points just draw straight lines be­tween all the pairs of points and then con­struct new straight lines at right an­gles to them pass­ing through their mid­points. Con­tinue each of these new bi­sect­ing lines until they en­counter an­other one, and then stop them. The re­sult is a net­work of Voronoi poly­gons.[1](part0106.html#ch83fn1) Each has one point at its cen­ter and the poly­gon around it maps out the part of space that is closer to it than to any other point.



This poly­gon de­fines a re­gion of dan­ger for the an­i­mal at its cen­tral point. If this an­i­mal’s re­gion of dan­ger is en­tered by a preda­tor, it will find it­self the near­est po­ten­tial prey. Each an­i­mal wants to make its poly­gon of dan­ger as small as pos­si­ble and to be as far as pos­si­ble from the preda­tor. This type of col­lec­tive be­hav­ior is called that of the “self­ish herd” be­cause each mem­ber acts in its own self-in­ter­est. Preda­tors like lions move around quickly, mak­ing the chang­ing Voronoi poly­gons dif­fi­cult to de­ter­mine in real sit­u­a­tions, even though a com­puter pro­gram can eas­ily come up with pre­dic­tions. You need a slow-mov­ing preda­tor–prey sce­nario.

In­ter­est­ing stud­ies have been done by film­ing the dy­nam­ics of large groups of fid­dler crabs when they feel threat­ened.[2](part0106.html#ch83fn2) Crabs are slow enough and small enough in num­ber to en­able care­ful stud­ies of their move­ment be­fore and after a preda­tor threat­ens. They ap­pear to fol­low the self­ish-herd be­hav­ior very closely, form­ing a pat­tern with large Voronoi poly­gons around each of them when the threat first arises. Next, they enter a panic mode in which they be­come much closer to each other with a smaller Voronoi pat­tern, each try­ing to keep some­one else be­tween it­self and the preda­tor. The threat­ened crabs do not nec­es­sar­ily scut­tle away from the preda­tor. They tend to move to­ward the cen­ter of their group (or “cast”) so as to put oth­ers be­tween them and the preda­tor:

Some­times this means ac­tu­ally run­ning to­ward the preda­tor. Re­mem­ber, an in­di­vid­ual’s level of risk is pro­por­tional to the area of the Voronoi poly­gon defin­ing its re­gion of dan­ger. These areas all be­come smaller when the crabs panic and get closer to­gether and every­one feels safer. Evo­lu­tion­ary bi­ol­o­gists teach us that those crabs that are less in­clined to fol­low this be­hav­ior will be more likely to get picked off by a preda­tory sea bird, while those that in­stinc­tively re­spond quick­est will be most likely to sur­vive to pro­duce off­spring that share that trait.

