Thoughts on acute vs. chronic infections

Today, we showed using the energy budget model for parasites of egesta/colon contents that it is possible to get bistability, where both the parasite extinction and endemic equilibria are stable simultaneously. This is an important finding, as other studies (see Fenton & Perkins 2010; Fenton, Lello, & Bonsall 2006) have pointed out that conventional immune-parasite models must treat acute vs. chronic as a modeling *assumption*, rather than a modeling *outcome.*

What we have shown is that the same model can produce acute vs. chronic outcomes depending on initial conditions (bistability). The key (I think) is the following. The stability of the parasite-free equilibrium depends on two things: the resource-dependent growth rate of the parasite and the mortality induced by the constitutive immune defense. If the difference between these two is negative, the parasite extinction equilibrium is stable and, presumably, the parasite cannot persist in the system. We showed that it can, largely because the parasite can increase its access to resources (in this case by reducing assimilation efficiency). The assumption that stability of the extinction equilibrium *necessitates* extinction is based on the idea that the parasite’s growth rate will never be so large as when it is invading the parasite-free system. With the parasite of colon contents, for example, the extinction stability condition is

where is the colon resource level at the parasite free equilibrium. If, indeed, *C* will never be as large as when the parasite is present, then there is no way that the parasite can ever invade, because as soon as it does, not only will *C* go down (due to resource consumption), but the induced immune response will kick in as well, driving the parasite back to extinction. However, in our model, the parasite reduces assimilation efficiency, so instead of *C* decreasing, it actually *increases*. This increase in *C* allows the parasite to persist, even in the presence of an induced immune response. However, if the increase in *C* is not fast enough, then the parasite is still at risk of extinction. Hence, bistability.

Another possible way to get bistability would be if the parasite can reduce the efficacy of the immune response (e.g. either reducing or ) from its baseline level.

These ideas, I think, hint at some general mechanisms for allowing acute vs. chronic infection to be a model outcome. What is really interesting is that helminths, a stereotypical chronic infection, often manipulate both resource availability *and* the immune response. I think it would be very worthwhile to consider exploring these questions with a very stripped down version of the models we have been investigating, just to investigate whether, indeed, bistability is a common outcome when you have parasite manipulation of either immune responses or resource availability.