DYNAMIC ENERGY BUDGETS 2005

– Subprogram Population Dynamics –

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DEB THEORY

I chose to follow the subprogram Population Dynamics, because in my research I will be more interested in the behaviour of the entire population, rather than that of a single individual. Another topic that I am interested in is the effect of non-essential compounds and their possible accumulation in the organisms.

The cornerstones of the DEB theory are mass and energy balances. For me – with a background in chemical engineering – this seems no more than logical if one wants to model e.g. the growth of an organism. However, I can understand that in biological systems it may not be so easy to construct for example a mass balance, due to the open boundaries of the system (environment). Another important aspect of the DEB theory, the incorporation of reserves and maintenance, also appeal to me and the book gives numerous examples of how these contribute towards a better explanatory character of the DEB theory, when compared to other theories.

In the subprogram on Population Dynamics, the focus is put on how to translate individual behaviour to population behaviour. The idea is that each individual has a certain probability to be in a certain state and the state of the population is then determined by the number of individuals, resulting in a structured population. This obviously is a better approach than simply assuming that all individuals are in the same state, as is done unstructured populations. Also discussed in chapter 9 are the possible interactions between different organisms, with the important notion that in most cases syntrophic interactions exist. The example of an idealised three-species ecosystem (canonical community) clearly shows the interactions between species. As mentioned by other participants in the course, building up a DEB model step-by-step, would greatly help towards understanding the DEB theory and how to work with it. I think the DEB model for the canonical community would be very useful for this purpose.

Chapter 10 gives an overview of the DEB theory and also a brief comparison with other theories. The latter was especially interesting to me, as I am not aware of how certain "problems" are dealt with in other theories. However, since the benefits of the DEB theory given in the book seem acceptable to me, it would also be interesting to know if there are topics that are maybe better described in other theories.

One general remark I would like to make about the DEB book is that it contains an overwhelming amount of mathematics. This does not necessarily have to be a problem, but what I often miss are the derivations of the posed equations (though some can be found in the comments file). Rather than assuming the result of an equation, I prefer to derive the posed equation myself. Not just to check whether the given equation is correct, but also to get a better understanding of what the equation represents. Maybe it would be a good idea to have a separate equations file, which contains the derivation of (all) the equations.

Application of DEB in my research

Biological processes are widely applied in municipal waste water treatment. Organic material and nutrients in the waste water are converted and inevitably new biomass (sludge) is formed. To maintain the desired density of micro-organisms in the process, some of the excess sludge will have to be withdrawn from the system. This excess sludge has to be treated as a waste material. In practise this means that most of it is incinerated. In my research I will look at reducing the amount of excess sludge through predation by aquatic oligochaetes. I will focus on a system, where the excess sludge is withdrawn from the waste water treatment process and predation by aquatic oligochaetes takes place in a separate process.

When the aquatic oligochaetes ("*worms*") predate on the excess sludge, some of this excess sludge (X) will be converted into worm-biomass (M_V and M_E) and some will be mineralised (maintenance products); what remains is defecated (product).

To prove that predation has an effect, I can make mass balances over the excess sludge, worms and faeces. This way I could show that there is a reduction in the amount of excess biomass (= excess sludge - faeces > 0) and that this reduction is larger than the increase in worm-biomass. However, I would also like to understand the process of predation better so that it can be operated under conditions where *excess sludge* - *faeces* - *worm-biomass* is the greatest (i.e. maintenance "losses" are the greatest). For this I think that the DEB theory can be a useful tool for me.

The main topics that I believe the DEB theory can be of use to me are:

- The conversion of excess sludge by worms: the available energy content μ_X and how much of it is spent on maintenance.
- The reproduction of worms, through the kappa rule there will be a certain allocation of energy towards reproduction. An interesting consequence of this is that reproduction can also take place when growth does not occur.

The main problem that I foresee is that the excess sludge itself is not a constant. Not only does its composition depend on the how the waste water treatment process is operated, but also after it is withdrawn from the process the composition will change. Since no new supply of waste water (X in the waste water treatment process) is available to this excess sludge, the reserves will be depleted, resulting in a change in the overall sludge composition. This will have its effect on the nutritional value of the excess sludge to the worms, as they will mainly feed on reserves, rather than structural mass.

If I want to create a proper DEB model for excess sludge predation, I will have to include the dynamics of the excess sludge and maybe even the dynamics of the waste water treatment process. This – to be honest – does not sound very appealing to me. I therefore think that the DEB theory will mainly have an explanatory use to me rather than being both explanatory and descriptive. What I mean is that with the DEB theory I can hopefully explain why certain things happen without actually constructing a specific DEB model.