Bachelor Thesis Project, SS 2020

Dynamic Energy Budget (DEB) model for Drosophila melanogaster under ad libitum feeding and starvation conditions.

Supervision:
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Research field:
Ecology & Neuroscience

Background of the Project

DEB theory is a formal theory capturing the energy/mass fluxes during the different life stages of a biological organism [1]. A species-specific DEB model can be fit with a minimal set of experimental observations [2]. Following the AmP estimation process (instructions can be found here), the minimal set of required parameters includes initial weights for all life stages, timing of transitions and maximum reproduction rate. The model can be then elaborated further to capture specific traits in more detail. Measuring the length of an organism during its life course allows predictions of bodily parameters via DEB's shape coefficient parameter, while measuring the ingested food mass allows computing the food-to-mass yield. There is a well-supported database online where DEB parameters for various species are maintained and updated.

There has been an adjustment of basic DEB theory for holometabolous insects that incorporates the additional puppa life stage [3]. DEB models have been fit for various insects. Interestingly, drosophila is not included in the online database, regardless of its crucial role as a model organism in neuroscience. Although growth curves and survival statistics have been within the scope of researchers, a DEB model has never been fit [4-6]. In fact, no representative species of the suborder brachycera is present. There are three species of diptera in total, all culicomorpha nematocera, of which the closest to the drosophilidae life history is the aedes aegypti mosquito.

In the context of behavioral science, one promising line of research attempts to couple behavioral regulation to energetic demands via hypothesis about the source of homeostatic drives. DEB has already been used as an operational theory providing the "search drive" that boosts exploration in starving animals [7]. Moreover, it has been used in combination with agent-based models for simulations of interacting populations of organisms [8]. Given the huge importance of drosophila for neuroscience, fitting a species-specific DEB model to drosophila life history is a prerequisite for any further bridging of neuroscience to ecological energetics.

Objective

This collaborative project combines experimental and theoretical approaches aiming to fit a basic DEB model for Drosophila melanogaster and further calibrate it for conditions of ad libitum feeding and food deprivation. The student will conduct a series of experiments to experimentally determine the growth curve of the Drosophila larva under two conditions: ad libitum feeding and starvation. She/he will then analyze her/his data and fit the parameters of the existing DEB model to explain the data.
Experimental supervision is provided by Dr. Thomas Riemensperger, Supervision of data analysis and modeling is provided by Panagiotis Sakagiannis and Prof. Dr. Martin Nawrot. The student will take part in regular lab events such as group meeting and journal club.

Experimental part
The candidate will perform the following:

1. **Minimal measurements for a DEB model under ad libitum feeding conditions :**
    1. Wet/dry initial weight of egg, larva, puppa and imago life stages as well as maximum imago weight.
    2. Timing of hatching, puppation, emergence and death.
    3. Combined weight and length of L1, L2, L3 larvas.
    4. Maximum reproduction rate of the same strain (mean number of eggs per day per fully mature female)

2. **Larva starvation experiments (time and food quantity dependent) :** Survival curves and puppation timing of larval populations deprived of food at different time points or having access to predefined food quantities:

    1. No food after hatching
    2. Defined quantity of food available per larva after hatching
    3. Food deprivation after 1,2,3 or 4 days of ad libitum feeding
    4. Ad libitum feeding

Computational part
The candidate will construct a **Dynamic Energy Budget model** through **:**

1. Use of measurements obtained in step 1 for fitting an initial DEB model
2. Use of measurements obtained in step 2 for calibrating the larval stage of the DEB model under starvation conditions

References

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