Time series of T. suecica densities under fluctuating temperatures experiment from May 2023 to Aug 2023

Website: https://www.bco-dmo.org/dataset/953492
Data Type: experimental
Version: 1
Version Date: 2025-02-21

Project
» A novel time-structured framework to account for the cryptic effects of temperature fluctuations on population dynamics (Time Structured Modeling)

Contributors	Affiliation	Role
Gouhier, Tarik C.	Northeastern University	Principal Investigator
Helmuth, Brian	Northeastern University	Co-Principal Investigator
Mickle, Audrey	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
This dataset includes the densities (count/mL) of the alga Tetraselmis suecica (LB 2286) cultures grown from a UTEX sample. The counts were obtained using a Beckman Coulter Z2 Particle Counter in the lab over a five-day period under different experimental temperature regimes. The experiment took place between 2023-05-23 and 2023-08-18. The goal of the experiment was to determine how mean temperature and temperature fluctuation frequency affected the growth rate of T. suecica. By comparing the growth rate of T. suecica under constant vs. variable temperatures, one can determine the historical or legacy effects of past temperature variation on subsequent organismal performance. These experiments were conducted by members of the Brian Helmuth Lab at Northeastern University.

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Coverage

Location: The original strain of T. suecica was collected from La Spezia, Italy
Temporal Extent: 2023-05-23 - 2023-08-18

Methods & Sampling

Organism and Culturing

Tetraselmis suecica (UTEX LB 2286) was cultured in 250 mL Erlenmeyer flasks containing sterilized natural seawater. We used natural seawater as artificial seawater such as Instant Ocean has been shown to sometimes affect experimental outcomes (Pechenik et al. 2019). Seawater was sterilized using vacuum filtration to remove particulate matter and sediment, and subsequently autoclaved at 121ºC for 60 minutes. Non-experimental lineages were created at least every 10 days, and Micro Algae Grow nutrient media (Florida Aqua Farms Inc., Dade City, FL) was added every day beginning on day 0 to prevent nutrient limitation. These

cultures were used to seed the experiments. Stock cultures were maintained in Darwin environmental chambers (Darwin Chambers Company, St. Louis, MO) at a constant temperature of 20ºC under continuous light provided by LED light strips. Stock cultures were gently swirled for 10 seconds daily to ensure homogeneity and proper aeration.

Experimental Setup

The experimental design involved acclimating cultures to eight different base temperatures (10ºC, 15ºC, 18ºC, 20ºC, 25ºC, 28ºC, 30ºC, 35ºC) over the course of 5 days in a Darwin environmental chamber. At the beginning of the experiment, cultures were placed on Peltier devices (Adafruit, New York, NY) housed in plastic egg-crate cages to prevent spillage. White LED strip lights were fastened inside the cages. Light was measured using a PAR sensor to verify that each cage was receiving at least 150 µmol m^{-2} s^{-2} (saturating irradiance (Bernhardt et al., 2018), and under 200 µmol m^{-2} s^{-2} to maintain consistent light conditions between cages.

Temperature Control and Manipulation

To control temperature during the experiment, we used TEC (thermoelectric cooling) Controllers (Meerstetter Engineering, Rubigen, Switzerland) to control the Peltier devices. Cultures were exposed to one of 5 fluctuating temperature treatments +/- 5ºC around the base temperature, or the constant temperature (n=18 per base temperature, n=3 per treatment within each base temperature). The five fluctuating temperature treatments for each mean temperature were characterized by the following frequencies: (i) frequency of 1 or period of 144 hours, (ii) frequency of 3 or period of 48 hours, (iii) frequency of 6 or period of 24 hours, (iv) frequency of 18 or period of 8 hours, and (v) frequency of 24 or period of 6 hours.

In order to ensure that cultures were in the exponential growth phase for the duration of the experiment, we used cultures at a known concentration of between 1,000,000 and 2,000,000 cells/mL on Day 1 of the experiment. To achieve this, we inoculated cultures the previous week at a lower concentration (i.e. 25,000 cells/mL) such that they would reach 1,000,000 by the end of their pre-experimental acclimation period. This lower concentration depended on the temperature to which they were being acclimated, as cultures further away from their T_{OPT} would grow more slowly.

Cells were counted daily for each of the five days using a Beckman Coulter Z2 Particle Counter (Beckman Coulter, Indianapolis, IN) set to count particles between 5–16 µm. This size range was experimentally determined by photographing cells on a Hemacytometer and analyzing size with ImageJ (version 1.54). Samples were diluted in ISOTON II Diluent (Beckman Coulter, Indianapolis, IN), with a dilution factor such that cell counts ranged from 10,000 to 200,000 before factoring in a dilution factor. Three samples were taken per culture, and three counts were run on each sample to ensure consistency.

Data Processing Description

The raw data are provided (no processing performed).

BCO-DMO Processing Description

- Imported "experimental_data.csv" into BCO-DMO system
- Converted datetime to ISO format (added 'T' between the date and time) and converted to UTC
- Renamed "full_date" to "measurement_datetime"
- Exported file as "953492_v1_tsuecica_exp.csv"

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Data Files

File
953492_v1_tsuecica_exp.csv (Comma Separated Values (.csv), 81.07 KB) MD5:9a87b566acde4eebf1a7a503bdb223e9 Primary data file for dataset ID 953492, version 1

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Related Publications

Bernhardt, J. R., Sunday, J. M., Thompson, P. L., & O'Connor, M. I. (2018). Nonlinear averaging of thermal experience predicts population growth rates in a thermally variable environment. Proceedings of the Royal Society B: Biological Sciences, 285(1886), 20181076. https://doi.org/10.1098/rspb.2018.1076
Methods

Pechenik, J. A., Levy, M., & Allen, J. D. (2019). Instant Ocean Versus Natural Seawater: Impacts on Aspects of Reproduction and Development in Three Marine Invertebrates. The Biological Bulletin, 237(1), 16–25. https://doi.org/10.1086/705134
Methods

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Parameters

Parameter	Description	Units
full_ID	ID of each row based on mean temperature, treatment, replicate ID, and technical replicate number	unitless
measurement_datetime	The date and time of the density measurements	unitless
days_since_start	Number of days since the start of each growth experiment	days
temperature	Mean temperature	degrees Celsius
treatment	Frequency of fluctuations (F1 = frequency of 1 or period of 144 hours; F3 = frequency of 3 or period of 48 hours; F6 = frequency of 6 or period of 24 hours; F18 = frequency of 18 or period of 8 hours; F24 = frequency of 24 or period of 6 hours; CON = constant temperature)	unitless
replicate	Experimental replicate ID (A, B, or C)	unitless
count_replicate	(Technical) replicate count for each unique experimental replicate (i, ii, or iii)	unitless
final_count	Number of T. suecica cells per mL	cells/mL

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Instruments

Dataset-specific Instrument Name	Darwin environmental chambers
Generic Instrument Name	Algal Growth Chamber
Dataset-specific Description	Stock cultures were maintained in Darwin environmental chambers (Darwin Chambers Company, St. Louis, MO) at a constant temperature of 20ºC under continuous light provided by LED light strips.
Generic Instrument Description	A chamber specifically designed for the growth of algae in flasks. The chamber typically provides controlled temperature, humidity, and light conditions.

Dataset-specific Instrument Name	Beckman Coulter Z2 Particle Counter
Generic Instrument Name	Coulter Counter
Dataset-specific Description	Cells were counted daily for each of the five days using a Beckman Coulter Z2 Particle Counter (Beckman Coulter, Indianapolis, IN) set to count particles between 5µm - 16 µm.
Generic Instrument Description	An apparatus for counting and sizing particles suspended in electrolytes. It is used for cells, bacteria, prokaryotic cells and virus particles. A typical Coulter counter has one or more microchannels that separate two chambers containing electrolyte solutions. from https://en.wikipedia.org/wiki/Coulter_counter

Dataset-specific Instrument Name	Hemacytometer
Generic Instrument Name	Hemocytometer
Dataset-specific Description	This size range was experimentally determined by photographing cells on a Hemacytometer and analyzing size with ImageJ.
Generic Instrument Description	A hemocytometer is a small glass chamber, resembling a thick microscope slide, used for determining the number of cells per unit volume of a suspension. Originally used for performing blood cell counts, a hemocytometer can be used to count a variety of cell types in the laboratory. Also spelled as "haemocytometer". Description from: http://hlsweb.dmu.ac.uk/ahs/elearning/RITA/Haem1/Haem1.html.

Dataset-specific Instrument Name	PAR sensor
Generic Instrument Name	Photosynthetically Available Radiation Sensor
Dataset-specific Description	Light was measured using a PAR sensor to verify that each cage was receiving at least 150 µmol m-2 s-2 (saturating irradiance (Bernhardt et al, 2018), and under 200 µmol m-2 s-2 to maintain consistent light conditions between cages.
Generic Instrument Description	A PAR sensor measures photosynthetically available (or active) radiation. The sensor measures photon flux density (photons per second per square meter) within the visible wavelength range (typically 400 to 700 nanometers). PAR gives an indication of the total energy available to plants for photosynthesis. This instrument name is used when specific type, make and model are not known.

Dataset-specific Instrument Name	vacuum filtration
Generic Instrument Name	water filtration device
Dataset-specific Description	Seawater was sterilized using vacuum filtration to remove particulate matter and sediment, and subsequently autoclaved at 121ºC for 60 minutes.
Generic Instrument Description	A manufactured device which is used to remove contaminants from water impeding the flow of particles or solutes.

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Project Information

A novel time-structured framework to account for the cryptic effects of temperature fluctuations on population dynamics (Time Structured Modeling)

NSF Award Abstract:
Although it is well established that temperature extremes associated with heatwaves or cold snaps can have strong and immediate impacts on biological populations, much less is known about the longer-term effects of these short-term events. The investigators are filling this critical knowledge gap by conducting a series of laboratory experiments and developing a new set of mathematical models to identify how temperature fluctuations influence population growth and size. Additionally, the mathematical models are being extended to generate a baseline understanding of how changes in temperature anticipated under global climate change will likely affect populations around the globe over the course of the 21st century. This project addresses important societal needs by cross-training graduate students in biology, statistics, mathematical modeling, and computer programming. The results of this research are being integrated into undergraduate courses in biostatistics, mathematical modeling, and environmental science in order to demonstrate the importance of quantitative and interdisciplinary STEM training for addressing important questions in biology. Finally, multiple interactive web modules are being created to disseminate the results of this research beyond academic circles, including Northeastern University’s K-12 outreach programs.

Current empirical and theoretical approaches do not account for the cryptic population structure that emerges when organisms are exposed to variable temperature regimes. The investigators are addressing this limitation by using marine algae as a model system to (i) establish an empirical protocol for properly evaluating the effects of temperature variability on population growth, (ii) develop a novel mathematical modeling framework for accurately predicting the dynamics of populations exposed to temperature fluctuations, and (iii) determine species extinction risk under future ocean temperatures. Overall, this project is expected to yield a new set of empirical and theoretical tools to better forecast the biological effects of environmental change.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using

the Foundation's intellectual merit and broader impacts review criteria.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2048894

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