Data for designing microalgal consortia for higher yield

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ABSTRACT

The data reported here were directly used in the research article entitled “A novel approach to build algal consortia for sustainable biomass production (Mandal and Corcoran, 2022)”. Data were collected to (1) generate microalgal consortia through a functional diversity approach and (2) test generated consortia against monocultures. Algal trait data (i.e., growth rate, carrying capacity) related to light, temperature, and salinity were collected in thirteen Nannochloropsis and Microchloropsis strains grown under different resource levels/conditions. Trait values were used in an in-silico method to calculate the functional diversity index (FDi) in all possible consortia (8178 combinations). Two metrics, the Net Biodiversity Effect (NBE) and Overyielding (OY), were used to assess the utility of this functional dispersion approach in consortia building for algal production.

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Specifications Table

| Subject                | Biology                     |
|-----------------------|-----------------------------|
| Specific subject area | Microalgal biotechnology, aquatic ecology |
| Type of data          | Table                       |
| How the data were     | Optical density was measured using a microplate reader (SpectraMax M5, Molecular Devices, USA) |
| Data format           | Raw                         |
| Description of data collection | Data collection was described in the Experimental Design, Materials, and Methods section of the publication |
| Data source location  | Los Alamos, New Mexico, United States of America |
| Data accessibility    | Repository name: Mendeley Data | Data identification number: 10.17622/srjs5ckkys.1 |
| Direct URL to data    | https://data.mendeley.com/datasets/srjs5ckkys |
| Related research article | S. Mandal, A. A. Corcoran, A novel approach to build algal consortia for sustainable biomass production. Algal Res. 65 (2022) 102,734. https://doi.org/10.1016/j.algal.2022.102734, [1]. |

Value of the Data

- The data provide knowledge on selecting productive microalgal consortia using a functional diversity approach.
- The datasets contain the physiological characterization of thirteen strains of *Nannochloropsis* and *Microchloropsis* with potential for biotechnological applications. The data can be used to develop growth models, as well as select strains for future applications of algae.
- The information on the functional diversity index is useful to the field of ecology, specifically diversity-productivity studies.

1. Data Description

We monitored the growth of thirteen *Nannochloropsis* and *Microchloropsis* strains cultivated at different levels of irradiance, temperatures, and salinities by measuring optical density at 750 nm. Growth data of the strains across different resource levels/conditions are provided in Supplementary Table 1, 2, and 3 for light (18, 38, 85, 118, 152, 220, 300, 470 μmol m⁻¹ s⁻¹), temperature (10, 19, 25, 29 and 35 °C) and salinity (5, 10, 15, 20, 25, 30), respectively in the repository Mendeley Data [2]. The functional diversity index (FDi) of 8178 possible combinations of consortia with 13 microalgal strains were calculated (Supplementary Table 4) and selected the most diverse (top 50) to test against monocultures in a well plate experiment [2]. The raw growth data of the 50 consortia and monocultures are presented in Supplementary Table 5 [2]. The calculated net biodiversity effect (NBE) and overyielding (OY) values are provided in Fig. 1 with raw data in Supplementary Table 5. The data in Table 1 show the effect of consortium type and salinity on the NBE and OY at the second harvest point. The regression analysis of FDi against NBE and OY are shown in Table 2. Although there are limitations of this study (see Discussion of (1)), these data contribute to the body of knowledge on the relationship between productivity and diversity. Specifically, they suggest that the strength of productivity-diversity relationships depends on functional traits.
Table 1
ANOVA table showing the effect of strain composition and salinity on the net biodiversity effect (NBE) and overyielding (OY) on day 14 (the second harvest point).

| Variable | Factor           | Df  | Sum Sq | mean Sq | F value | Pr(>|F|) |
|----------|------------------|-----|--------|---------|---------|---------|
| NBE      | Composition      | 49  | 90.5   | 1.848   | 6.20    | <2e-16  |
|          | Salinity         | 1   | 0.9    | 0.950   | 3.18    | 0.076   |
|          | Composition x Salinity | 49  | 6.0    | 0.122   | 0.41    | 1.000   |
|          | Residuals        | 200 | 59.6   | 0.298   |         |         |
| OY       | Composition      | 49  | 89.3   | 1.821   | 6.11    | <2e-16  |
|          | Salinity         | 1   | 0.8    | 0.838   | 2.81    | 0.095   |
|          | Composition x Salinity | 49  | 5.9    | 0.120   | 0.40    | 1.000   |
|          | Residuals        | 200 | 59.6   | 0.298   |         |         |

Table 2
ANOVA table showing the effect of FDi in the regression model predicting the net biodiversity effect (NBE) and overyielding (OY). Data were fitted to a linear function for each experimental phase.

| Variable | Coefficient | Estimate ± Standard Error | t value | Pr(>|t|) |
|----------|-------------|---------------------------|---------|---------|
| NBE      | Intercept   | −0.0813 ± 0.164           | −0.49   | 0.621   |
|          | FDi         | 0.1423 ± 0.067            | 2.12    | 0.034   |
| OY       | Intercept   | −0.4187 ± 0.1705          | −2.46   | 0.014   |
|          | FDi         | 0.2072 ± 0.0698           | 2.97    | 0.003   |
2. Experimental Design, Materials and Methods

The materials and methods are described in the related research article [1]. In brief, we measured a suite of traits relevant for outdoor cultivation in thirteen *Nanochloropsis* and *Microchloropsis* strains. We used trait values in the FD package in R to measure a functional diversity index (FDi) in all possible 8178 combinations of the 13-strain pool. Specifically, the dbFD function in this package calculated the FDi of each species combination based on the weighted average distance to the centroid [3]. We selected the 50 most diverse consortia (greatest FDi values) and compared their growth to monoculture. Each strain or strain combination (50 consortia and 10 monocultures) was grown in 24 well plates with algal growth media [1] and replicated 6 times. This experiment was continued for 21 days with three harvest cycles, each with a different set of cultivation conditions. For the first 7 days of the experiment, cultures were incubated at a salinity of 16, on a 12:12 light dark cycle, with diurnal light (95 and 430 mE m$^{-2}$ s$^{-1}$) and temperature (15 to 33 °C) regimes. After one week, we diluted each culture to an optical density of ∼0.2 with two media versions to impose a salinity shock, resulting in three biological replicates per treatment with a final salinity of 16 and three biological replicates per treatment with a final salinity of 5. One week later, we diluted the cultures with media at a salinity of 16 to an optical density of ∼0.2 and simulated a cold event. Specifically, we changed the temperature regime to impose fluctuations between 8 and 14 °C. To compare the yield of consortia to that of monocultures, we calculated two metrics: NBE and OY, as:

\[
\text{NBE} = X_o - X_E
\]

\[
\text{OY} = X_o - X_{\text{max}}
\]

where:

- $X_o$ = Consortia yield (optical density).
- $X_E$ = Expected yield calculated from the mean of optical density of each component species when grown as monocultures.
- $X_{\text{max}}$ = Yield of the most productive strain present in the consortia when grown as a monoculture.

General linear models were fit using the gls() function in R to test for effects of FDi on the NBE and OY. Detailed data are accessible through the research article [1].

Ethics Statements

No conflicts, informed consent, or human or animal rights are applicable to this study.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data for designing microalgal consortia for higher yield (Original data) (Mendeley Data).

CRediT Author Statement

Shovon Mandal: Visualization, Formal analysis, Writing – original draft, Writing – review & editing; Alina A. Corcoran: Visualization, Writing – original draft.
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