**Supplementary material**

* **Tropical seagrass *Halophila stipulacea* shifts thermal tolerance during Mediterranean invasion**
* Marlene Wesselmann1, Andrea Anton2, Carlos M. Duarte2, Iris E. Hendriks1, Susana Agustí3, Ioannis Savva4, Eugenia T. Apostolaki5, Núria Marbà1
* 1Global Change Research Group, IMEDEA (CSIC-UIB), Institut Mediterrani d’Estudis Avançats, Miquel Marquès 21, 07190, Esporles, Illes Balears, Spain
* 2Red Sea Research Centre (RSRC) and Computational Bioscience Research Center (CBRC), King Abdullah University of Science and Technology (KAUST), Thuwal, Saudi Arabia
* 3 Red Sea Research Centre (RSRC), King Abdullah University of Science and Technology (KAUST), Thuwal, Saudi Arabia
* 4Marine and Environmental Research (MER) Lab, Limassol 4533, Cyprus
* 5Institute of Oceanography, Hellenic Centre for Marine Research, PO Box 2214, 71003 Heraklion, Crete, Greece
* \*Corresponding author: [m.wesselmann@imedea.uib-csic.es](mailto:m.wesselmann@imedea.uib-csic.es)

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* Table S1: Experiments date, temperature, depth, *in situ* (~control) temperature, treatment temperatures and Inorganic nutrient concentration (Mean ± SD) of the water used for experiments (P>0.05; obtained from ANOVA).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| * Experiment | * Donor population | * Date of collection | * *In situ* and control T (°C) | * Depth (m) | * Experimental * treatment * T (°C) | * NO3-1 + NO2-1 * (mg l-1) | * PO4-3   (mg l-1) |
| * Lower range | * Greece | * 03/04/18 | * 17 | * 8 | * 8, 11, 14, 17, 20, 25 | * 0.015 ±0.01 | * 0.02 * ±0.00 |
| * Cyprus | * 13/03/18 | * 17 | * 4 | * 8, 11, 14, 17, 20, 25 |
| * Red Sea | * 12/11/17 | * 29 | * 2 | * 8, 11, 14, 17, 20, 25 | * 0.05 ±0.01 | * 0.01 * ±0.00 |
| * Upper range | * Greece | * 23/07/17 | * 26.5 | * 8 | * 26.5, 29, 31.5, 34, 36, 38 | * 0.03 ± 0.02 | * 0.01 ± 0.00 |
| * Cyprus | * 08/09/17 | * 26.5 | * 4 | * 26.5, 29, 31.5, 34, 36, 38 |
| * Red Sea | * 28/01/18 | * 25 | * 2 | * 25, 29, 34, 36, 38, 40 | * 0.05 ±0.01 | * 0.01 * ±0.00 |

Table S2: Mean ± SE (Standard Error) growth and metabolic responses of *H. stipulacea* exposed at temperature treatments 25ºC and 29ºC when plants were previously acclimated at 25ºC and 29ºC for 6 days. P values were obtained from unpaired t-test.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Experimental treatment 25 **°**C acclimated at 29**°**C | | | Control treatment 25**°**C acclimated at 25**°**C | | | P value | Treatment 29**°**C acclimated at 25**°**C | | | Control treatment 29**°**C acclimated at 29**°**C | | | P value |
|  |
| Rhizome elongation (cm d-1) | 0.177 | ± | 0.026 | 0.222 | ± | 0.053 | 0.425 | 0.283 | ± | 0.049 | 0.308 | ± | 0.040 | 0.699 |
| Recruitment rate  (d-1) | 0.029 | ± | 0.007 | 0.034 | ± | 0.004 | 0.576 | 0.046 | ± | 0.006 | 0.047 | ± | 0.005 | 0.867 |
| Net population growth rate (d-1) | -0.005 | ± | 0.014 | 0.014 | ± | 0.019 | 0.397 | 0.029 | ± | 0.007 | 0.038 | ± | 0.009 | 0.511 |
| GPP  (mmol 02 g DW-1) | 6.819 | ± | 1.221 | 6.327 | ± | 1.280 | 0.795 | 10.111 | ± | 1.272 | 6.393 | ± | 1.00 | 0.083 |
| R  (mmol 02 g DW-1) | 3.669 | ± | 0.776 | 5.286 | ± | 1.329 | 0.313 | 6.468 | ± | 0.940 | 3.444 | ± | 0.738 | 0.063 |
| NP  (mmol 02 g DW-1) | 3.150 | ± | 0.826 | 3.081 | ± | 0.842 | 0.956 | 3.644 | ± | 0.501 | 2.949 | ± | 0.495 | 0.381 |

Table S3: Differences between the thermal tolerance curves for growth and metabolism among the three locations with an extra sum-of-squares F-test.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | F (df) | P value |
| Rhizome elongation rate ~ Temperature + location | | 24.57 (6, 367) | <0.0001 |
|  | Red Sea - Cyprus | 6.79 (3, 226) | 0.0002 |
|  | Red Sea - Greece | 17.46 (3, 226) | <0.0001 |
|  | Cyprus - Greece | 38.61 (3, 282) | <0.0001 |
| Shoot recruitment rate ~ Temperature + location | | 18.58 (6, 367) | <0.0001 |
|  | Red Sea - Cyprus | 1.15 (3, 226) | 0.3283 |
|  | Red Sea - Greece | 25.10 (3, 226) | <0.0001 |
|  | Cyprus - Greece | 29.30 (3, 282) | <0.0001 |
| Net population growth rate ~ Temperature + location | | 17.77 (6, 367) | <0.0001 |
|  | Red Sea - Cyprus | 1.46 (3, 226) | 0.2240 |
|  | Red Sea - Greece | 23.96 (3, 226) | <0.0001 |
|  | Cyprus - Greece | 19.16 (3, 282) | <0.0001 |
| GPP ~ Temperature + location | | 33.99 (6, 130) | <0.0001 |
|  | Red Sea - Cyprus | 35.93 (3, 86) | <0.0001 |
|  | Red Sea - Greece | 55.22 (3, 85) | <0.0001 |
|  | Cyprus - Greece | 5.19 (3, 89) | 0.00240 |
| R ~ Temperature + location | | 4.76 (6, 130) | 0.0002 |
|  | Red Sea - Cyprus | 1.67 (3, 86) | 0.1779 |
|  | Red Sea - Greece | 6.84 (3, 85) | 0.0003 |
|  | Cyprus - Greece | 4.61 (3, 89) | 0.0048 |
| NP ~ Temperature + location | | 15.22 (6, 130) | <0.0001 |
|  | Red Sea - Cyprus | 20.47 (3, 86) | <0.0001 |
|  | Red Sea - Greece | 16.71 (3, 85) | <0.0001 |
|  | Cyprus - Greece | 4.190 (3, 89) | 0.0080 |

Table S4: Shifts in biological traits of exotic species in recipient environments and the corresponding number of generations (N°*G*).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Group | Species | Biological trait assessed | N°*G* | Source |
| Bird | *Pitangus sulphuratus* | Body mass (g) and bill width (mm) | 17 | Maathys and Lockwood, 2009 |
| Reptile | *Rhinella marina* | Behavioural and morphological traits | 50 | Ross *et al*., 2009 |
| Fish | *Poecilia reticulata* | Male colour/ Sperm length Maturity | 3/14 | Gordon *et al*., 2017/ Reznick *et al*., 1990 |
| Fish | *Oncorhynchus nerka and O. mykiss* | Developmental rate/ Osmoregulatory genes | 14 | Aykanat *et al*., 2011 |
| Fish | *Thymallus thymallus* | Developmental traits | 22 | Kavanagh *et al*., 2010 |
| Fish | *Oncorhynchus tshawytscha* | Growth rate/ Population genetic structure | 26/10 | Kinnison *et al*., 1998, 2008 |
| Fish | *Salmo trutta* | Juvenile survival | 37 | Westley *et al*., 2012 |
| Fish | *Gambusia affinis* | Size at maturity | 110 | Stockwell and Weeks, 1999 |
| Insect | *Tribolium castaneum* | Faster growth and spread | 6 | Szücks *et al*., 2017 |
| Insect | *Callosobruchus maculatus* | Dispersal distance | 10 | Ochocki and Miller, 2017 |
| Insect | *Bemisia tabaci MEAM 1* | Survival, fecundity, and viability | 5-7 | Muñoz-Valencia *et al*., 2016 |
| Insect | *Drosophila subobscura* | Clinal variation in wing shape | 5-6 | Huey, 2000 |
| Plant | *Centaurea diffusa* | Growth and reproductive output | 50 | Turner *et al*., (2014) |
| Plant | *Hypericum canariense* | Growth rate, flowering and size | 25 | Dlugosh and Parker (2008) |
| Plant | *Avena barbata* | Earlier flowering | 5 | Nguyen *et al*., 2016 |
| Plant | *Bromus madritensis* | Earlier flowering, water-use efficiency | 5 | Nguyen *et al*., 2016 |
| Plant | *Hypericum perforatum* | Latitudinal clines in size and fecundity | 12-15 | Maron et al., 2004 |
| Plant | *Lythrum salicaria* | Biomass and height | 75 | Blossey and Nötzold, 1995 |
| Plant | *Carduus mutans* | Shoot mass | 25 | Willis *et al*., 2000; |
| Plant | *Spartina alterniflora* | Herbivore resistance index | 10 | Daehler and Strong, 1997; |
| Plant | *Digitalis purpurea, Echium vulgare and Senecio jacobea* | Shoot mass | 50 | Willis *et al*., 2000; Bone and Farres, 2001 |
| Plant | *Solidago altissima and S. gigantea* | Morphology and life history | 10-20 | Weber and Schmid, 1998 |
| Plant | *Halophila stipulacea* | Growth and metabolic rates | 175 | *This study* |

Table S4 references:

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**Supplementary figures**

**Figure S1**

* Macintosh HD:Users:marlene:Desktop:survival.pdf
* Figure S1: Survival curves of all three populations exposed to a wide temperature range (8-40ºC) fitted with a logistic growth model. The intersections of horizontal and vertical lines indicate the lethal thermal limits (LT50) provided in Table1.