Captive rearing of the deep-sea coral *Eguchipsammia fistula* from the Red Sea demonstrates remarkable physiological plasticity

Anna Roik, Till Röthig, Cornelia Roder, Paul Müller, Christian R Voolstra

Presence of the cosmopolitan deep-sea coral *Eguchipsammia fistula* has recently been documented from the Red Sea, occurring in warm ($>20^{\circ}\text{C}$), oxygen- and nutrient-limited habitats. We collected colonies of this species from the central Red Sea that successfully reside in aquaria for more than one year. During this period the corals were exposed to increased oxygen levels and nutrition *ad libitum* unlike in their natural habitat. Specimens of long-term reared *E. fistula* colonies were incubated for 24 hours and calcification (G) as well as respiration rates (R) were measured. In comparison to onboard measurements of G and R rates on freshly collected specimens, we found that G was increased while R was decreased. *E. fistula* shows extensive tissue growth and polyp proliferation in aquaculture and can be kept at conditions that differ notably from its natural habitat. Its ability to cope with rapid and prolonged changes in regard to prevailing environmental conditions indicates a wide physiological plasticity. This may explain in part the cosmopolitan distribution of this species and emphasizes its value as a deep-sea coral model to study mechanisms of acclimation and adaptation.

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INTRODUCTION

The existence of ahermatypic and azooxanthellate coral species, so-called deep-sea corals, in the Red Sea has been anecdotally reported more than a century ago (Marenzeller, 1906). However, not until recently the first live deep-sea coral specimens for biological measurements were collected from the Red Sea (Roder et al., 2013). The distribution of deep-sea corals depends on various environmental factors such as temperature, oxygen levels, aragonite saturation, sedimentary regimes, substrate properties, currents, and food availability (Roberts et al., 2009; Naumann, Orejas & Ferrier-Pagès, 2014; Gori et al., 2014b).

An applicable temperature range for reef building azooxanthellate corals in a global habitat-suitability model was estimated between 5 and 10 °C (Davies & Guinotte, 2011). Until recently, scleractinian azooxanthellate corals in the Mediterranean deep-sea (≤ 14 °C) were assumed to live at the upper limit of their thermal distribution range (Orejas et al., 2011a; Naumann, Orejas & Ferrier-Pagès, 2013). In contrast, the Red Sea provides a unique habitat with temperatures exceeding 20 °C throughout the water column. Additionally, low oxygen levels, a salinity level above 40 PSU, and little inorganic nutrients represent presumably challenging conditions for deep-sea corals (Edwards & Head, 1987; Roder et al., 2013; Qurban et al., 2014).

The coral *Eguchipsammia fistula* (Cairns, 1994) is known to occur in the Indo-Pacific, Australia, and New Zealand (van der Land, 2008). In the Red Sea, *E. fistula* has been found at least three times: in northern parts of the Red Sea [Marenzeller \(1906\)](#) found mostly dead or damaged coral colonies between 490 and 900m, whereas [Qurban et al. \(2014\)](#) observed alive corals at depth of 683 m. In the central Red Sea, Roder et al. (2013) reported the discovery of live specimens between 230 and 320 m. Roder et al. (2013) and Qurban et al. (2014) described habitat conditions highlighting a warm, saline, oxygen- and nutrient-poor environment. Roder et al. (2013) furthermore collected corals for metabolic measurements.

In this study we provide for the first time information on successful long-term rearing (> 1 year) of the azooxanthellate coral *E. fistula* collected from the Red Sea. To further understand the limitations that are posed by the distinct environmental constraints of the Red Sea and to assess physiological plasticity of the deep-sea coral *E. fistula*, we collected and compared calcification (G) and respiration (R) rates from long-term reared corals with on-board based measurements of specimens freshly collected from their natural habitat (Roder et al., 2013).

MATERIAL AND METHODS

Rearing conditions

E. fistula colonies were sampled from the central Red Sea (N22°17.831, E38°53.811 from 320 m) in May 2013 during leg 6 of the cruise ‘KRSE 2013’. Sampling was conducted using a ROV equipped with a custom-made shovel-like basket (scoop). On-board the RV ‘AEGAE0’ the corals were transferred into a closed aquaria system (six 110 L LDPE tanks for corals; one 240 L acrylic reservoir tank; Aqua Medic Ecorunner 3700 for water flow) filled with deep-sea water and equipped with a chiller (Aqua Medic Titan 1500; 21 ± 0.5 °C). Water exchange (deep-sea water, about 230 L per day) was ensured until the live corals were transferred to aquaria facilities at the King Abdullah University of Science and Technology (KAUST). Larger colonies were introduced unmodified into the rearing facilities. Smaller branches were either attached onto reef cement sockets (Reef Construct, Aqua Medic) or onto PVC plates with coral glue (Coral Construct, Aqua Medic). The rearing system consisted of a protein skimmer (Aqua Medic Turboflotor 5000 baby ECO), filter (trickling towers, Aqua Medic), and a 250 L reservoir tank. The corals were distributed in four 125 L tanks (L-LDPE containers with PVC lids, Bürkle, Germany) each equipped with submersible current pumps (Aqua Medic Nanoprop 5000) that create a constant current in the tanks (flow rate ~ 5000 L h⁻¹). Coral tanks, reservoir, skimmer, and filter were connected to an open flow batch system with a controlled temperature of 21.3 ± 0.3 °C (chiller

64 AquaEuroUSA MC-1/2 HP), which corresponds closely to the temperature of the corals' natural
65 habitat.

66 Water changes in this closed 750 L system were performed at a rate of 300 L per week using
67 unfiltered sea surface water collected from 14 km offshore of KAUST (approximately N22°
68 31.733, E38° 91.218). To reduce high salinity of surface water, reverse osmosis water (Milli-Q
69 System, Millipore) was added to adjust the salinity to 40-41 PSU. Corals were fed twice a week
70 *ad libitum* with *Mysis* (Crustacea, Eumalacostraca) and *Artemia* (Crustacea, Sarsostraca) (Ruto
71 Red Label frozen fish food in blister packages). After feeding, leftovers and other particulate
72 pollution (e.g. feces) were siphoned off the tanks. Corals were reared in darkness; only during
73 feeding and cleaning activities corals were sporadically exposed to light.

74 ***Physiology***

75 To assess physiological performance in long-term reared corals, we measured respiration (R) and
76 calcification (G) rates in five colonies. Prior to the experiment feeding was suspended for 5 days.
77 Similar sized (1-2 polyps) coral colonies were transferred without air exposure into custom-made
78 acrylic 2.3 L chambers filled with seawater from the coral rearing setup. Each chamber was
79 equipped with current pumps (flow rate $\sim 0.8 \text{ L min}^{-1}$). A control incubation was run in parallel
80 containing a bare coral skeleton in order to correct for a possible chamber effect. All chambers
81 were placed in a temperature-controlled water bath (chiller AquaEuroUSA MC-1/2 HP) and
82 corals were incubated for 24 h. We measured oxygen concentration, temperature, and salinity at
83 start and end of the incubation using a portable Multi-Parameter Meter (HACH HQ40d ©). We
84 determined R and G as described in Schneider & Erez (2006): we derived R from the depletion of
85 dissolved oxygen over the 24 h incubation and subtracted variations in oxygen concentrations in
86 the control chamber from the coral incubations.

87 G was determined applying the total alkalinity (TA) depletion method. Seawater samples (50 mL)
88 were taken in duplicates before and after the incubation from each chamber using $0.45 \text{ } \mu\text{m}$

syringe filters. Filtered TA samples were stored (1-2 h) at a stable temperature (21 °C) before automated acidimetric titration (Titrando 888, Metrohm AG, Switzerland). Correction of TA values for coral specimens was performed by subtracting control chamber values. Values were calculated as respiration and calcification rate per hour and normalized to coral tissue surface area. Live tissue cover was determined using the geometric approximation method (Naumann et al., 2009) and ranged between 45 and 91 cm².

Calcification and respiration of freshly collected *E. fistula* specimens were assessed as described in Roder et al. (2013): five replicates were incubated for 60 – 80 min in 1 L glass beakers on-board during the cruise ‘KRSE 2011’. Further details are available in Roder et al. (2013).

Statistical analysis

All measurements in this study were determined as means $\pm$ SD. We compared the respiration and calcification rates between captive *E. fistula* (this study) and freshly collected specimens from Roder et al. (2013). To assess differences between our 24 h incubation experiment of captive *E. fistula* (n = 5) and measurements from Roder et al. (2013) from 60 – 80 min incubations of freshly collected specimens (n = 5), the non-parametric Mann–Whitney *U*-test was applied using Statistica 10 (StatSoft Inc. 2011, version 10), as data were not normally distributed (Lilliefors test, $p < 0.05$). Results were regarded as statistically significant at $p < 0.05$.

RESULTS AND DISCUSSION

Rearing conditions

To assess physiology of the deep-sea coral *E. fistula* from the Red Sea we established a basic aquaria-based rearing system (see Materials and Methods). Salinity, temperature, and pH were similar compared to the natural habitat, but oxygen, total alkalinity (TA), and aragonite saturation state differed from the corals' natural Red Sea habitat (Table 1). Lower TA and aragonite saturation state (Ω_{arg}) values in the aquaculture were a result of added MilliQ water to adjust surface water salinity to 40-41 PSU. Due to aeration of the seawater storage container, oxygen levels were increased in aquaculture. The increase in dissolved oxygen concentrations did not have any noticeable detrimental effects on *E. fistula*. Furthermore, reared coral specimens did not seem to be affected by changes of water density/pressure (between deep-sea and rearing conditions) contrary to other azooxanthellate corals (Dullo, Flögel & Rüggeberg, 2008; Naumann, Orejas & Ferrier-Pagès, 2013).

Phenotypic differences

More than 90% of coral colonies survived (for more than one year) under the here-described rearing conditions. During this period, we observed notable tissue expansion and polyp proliferation. Captive corals displayed increased tissue thickness and tissue regrowth over former bare skeleton and even over substrate that the corals were fixed to (Fig. 1b). Furthermore, larger sized polyps divided and/or new polyps budded at the distal end of long-term reared coral colonies (Fig. 1c). In contrast, freshly-collected *E. fistula* live tissue covered only the distal end (tip) of colony branches (Fig. 1a) (Roder et al., 2013).

Respiration rates

Given our observation of tissue extension and polyp proliferation in aquaculture, we tested for an increase in metabolic activity. To do this, we compared respiration rates from incubations of

long-term reared coral specimens to on-board collected measurements of *E. fistula* (Roder et al., 2013). Long-term reared corals were incubated under moderately different conditions than on-board measurements: Salinity, temperature, and oxygen rates were higher; pH, TA, and Ω_{arg} were lower (Table 2).

For the 24 h incubations of aquaria-reared corals, we found a decrease in O_2 concentration from 8.54 to 0.98 $\text{mg O}_2 \text{ L}^{-1}$ over 24 h caused by respiratory processes. Oxygen levels from the control chamber indicated that a distinct portion of this respiration was not caused by the corals, where we measured a decrease from 8.63 to 2.22 $\text{mg O}_2 \text{ L}^{-1}$ over 24 h. Therefore the control respiration was subtracted from the coral incubations. The resulting average respiration rate of *E. fistula* in aquaculture was $1.75 \pm 0.78 \mu\text{g O}_2 \text{ cm}^{-2} \text{ h}^{-1}$. Interestingly, this is about 50 % less compared to the average respiration rate of freshly collected specimens that were measured on-board (Roder et al., 2013) (Table 2). However, the difference in respiration rate was not statistically significant ($p_{\text{Utest}} = 0.06$) (Fig. 2a).

Naumann, Orejas & Ferrier-Pagès (2014) found average respiration rates of $6.40 \pm 1.73 \mu\text{g O}_2 \text{ cm}^{-2} \text{ h}^{-1}$ (corresponding to $4.8 \pm 1.3 \mu\text{mol O}_2 \text{ cm}^{-2} \text{ d}^{-1}$) for *Lophelia pertusa* and $5.33 \pm 1.07 \mu\text{g O}_2 \text{ cm}^{-2} \text{ h}^{-1}$ (corresponding to $4.0 \pm 0.8 \mu\text{mol O}_2 \text{ cm}^{-2} \text{ d}^{-1}$) for *Madrepora oculata*. For the same two species, Gori et al. (2014a) found distinctive lower average respiration rates of $0.78 \pm 0.25 \mu\text{g O}_2 \text{ cm}^{-2} \text{ h}^{-1}$ (corresponding to $0.47 \pm 0.15 \mu\text{mol C cm}^{-2} \text{ d}^{-1}$) and $1.07 \pm 0.23 \mu\text{g O}_2 \text{ cm}^{-2} \text{ h}^{-1}$ (corresponding to $0.64 \pm 0.14 \mu\text{mol C cm}^{-2} \text{ d}^{-1}$), respectively. Furthermore, the authors reported average respiration rates of $2.23 \pm 0.52 \mu\text{g O}_2 \text{ cm}^{-2} \text{ h}^{-1}$ (corresponding to $1.34 \pm 0.31 \mu\text{mol C cm}^{-2} \text{ d}^{-1}$) for *Desmophyllum dianthus* and $2.62 \pm 0.53 \mu\text{g O}_2 \text{ cm}^{-2} \text{ h}^{-1}$ (corresponding to $1.57 \pm 0.32 \mu\text{mol C cm}^{-2} \text{ d}^{-1}$) for *Dendrophyllia cornigera*. In another study Gori et al. (2014b) found similar average maximum respiration rates for *D. cornigera* of $4.00 \pm 0.83 \mu\text{g O}_2 \text{ cm}^{-2} \text{ h}^{-1}$ (corresponding to $2.4 \pm 0.5 \mu\text{mol C cm}^{-2} \text{ d}^{-1}$). One of the highest respiration rates, $5.00 \pm 1.33 \mu\text{g O}_2 \text{ cm}^{-2} \text{ h}^{-1}$ (corresponding to $3.0 \pm 0.8 \mu\text{mol C cm}^{-2} \text{ d}^{-1}$), was reported by Naumann et al. (2011) from

zooplankton-fed *D. dianthus* specimens. In comparison, respiration rates of *E. fistula* are within the range of those determined for other azooxanthellate corals from colder habitats, but interestingly, at the lower end of the range, despite a distinctively higher water temperature ($> 21^{\circ}\text{C}$).

Calcification rates

In addition to respiration, we assessed calcification rates of reared *E. fistula* via the TA depletion method. The control chamber showed enriched TA values at the end of the incubation (after 24 h) with a difference of $16.36 \mu\text{mol TA kg}^{-1}$. Thus, TA values were control corrected. The control corrected TA depletion method comprised values between 6.91 and $34.32 \mu\text{mol TA kg}^{-1}$. We subsequently calculated an average calcification rate of $0.013 \pm 0.01 \mu\text{mol CaCO}_3 \text{ cm}^{-2} \text{ h}^{-1}$ for long-term captive *E. fistula*.

Comparison of calcification rates from long-term captive *E. fistula* with results obtained from on-board incubations of freshly collected specimens by Roder et al. (2013) on average demonstrates a 6-fold increase of calcification rates for captive-reared corals (Fig. 2b). Yet, due to a high variance associated with the on-board measurements, the difference was not statistically significant ($p_{\text{Utest}} = 1.0$). In this study and in Roder et al. (2013) no correction for NH_4^+ effect on TA depletion method was performed, which has been shown to potentially underestimate calcification rates by up to 10 % (Maier et al., 2012).

Calcification in *D. cornigera* (an azooxanthellate species from the same family of *Dendrophyllidae*) ranged between 0.017 and $0.079 \mu\text{mol CaCO}_3 \text{ cm}^{-2} \text{ h}^{-1}$ at temperatures up to 16°C (Gori et al., 2014b). Calcification rates for *E. fistula* compared to *D. cornigera* are similar despite higher water temperatures ($> 21^{\circ}\text{C}$). It remains to be determined whether calcification of *E. fistula* from cold water environments and the Red Sea display similar rates at their corresponding prevailing habitat temperature, and accordingly if a relative, not an absolute

increase in temperatures enhances calcification as has been shown for other corals (Naumann, Orejas & Ferrier-Pagès, 2013, 2014).

Effect of diet

It has been argued previously that reduced tissue cover and growth rates might represent coral adaptations to ‘deep-sea conditions’ in the Red Sea (Roder et al., 2013). Although there is no information available on the natural diet of *E. fistula* in the Red Sea, food sources for other azooxanthellate corals have been described as phytodetritus, phytoplankton, (zoo)plankton and dissolved organic matter (Gori et al., 2014a). As observed for captive *E. fistula*, regular feeding and uptake of crustaceans is in line with the earlier reported hypothesis of other deep-sea corals capturing and utilizing (zoo)plankton (Dodds et al., 2009; Qurban et al., 2014). An increased food supply in captivity can result in increased growth as reported for other azooxanthellate corals (Orejas et al., 2011b), or conversely decreased growth when feeding is omitted (Naumann et al., 2011). We could confirm that regular feeding and elevated oxygen levels (among others) induced increased tissue extension, polyp proliferation, and calcification rates (by trend) in *E. fistula* (Fig. 1, Fig. 2).

Experimental variables

Considering increased growth, food uptake, and available oxygen, the here-measured decrease (by trend) in respiration of captive-reared corals in comparison to freshly collected specimens seems less plausible. However, higher respiration rates in the on-board measurements might be interpreted as a response to stress (Dodds et al., 2007), possibly caused by the sampling procedure and rapidly changing environment from the depth to on-board incubation beakers (Hennige et al., 2014). These effects may also explain the higher variation in calcification of freshly collected corals (Roder et al., 2013) compared to long-term reared *E. fistula* (Fig. 2b).

CONCLUSION

203 Our results show successful transferal of *E. fistula* coral specimens from nutrient- and oxygen-
 204 limited deep-sea habitats of the Red Sea into a rearing system that only in part corresponds to its
 205 natural environment. In contrast to other azooxanthellate coral species (Naumann et al., 2011),
 206 *E. fistula* is easy to maintain in a basic aquaria system demonstrating a wide physiological
 207 plasticity. The ability to cope with a wide range of physico-chemical conditions might be one of
 208 the clues to the cosmopolitan success of this species as well as to the feasibility of aquaria rearing
 209 in markedly different conditions compared to the species natural habitat. Comparative
 210 experiments with *E. fistula* from different environments (e.g. Red Sea, Indo-Pacific, Australia,
 211 and New Zealand) in connection with population genetics studies will further reveal the extent of
 212 plasticity and connectivity to elucidate the ability of this widespread species to cope with
 213 environmental change.

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References

- Cairns S. 1994. *Scleractinia of the temperate North Pacific*. Washington D.C.: Smithsonian Institution Press.
- Davies AJ, Guinotte JM. 2011. Global Habitat Suitability for Framework-Forming Cold-Water Corals. *PLoS ONE* 6:e18483.
- Dodds L, Black K, Orr H, Roberts J. 2009. Lipid biomarkers reveal geographical differences in food supply to the cold-water coral *Lophelia pertusa* (Scleractinia). *Marine Ecology Progress Series* 397:113–124.
- Dodds LA, Roberts JM, Taylor AC, Marubini F. 2007. Metabolic tolerance of the cold-water coral *Lophelia pertusa* (Scleractinia) to temperature and dissolved oxygen change. *Journal of Experimental Marine Biology and Ecology* 349:205–214.
- Dullo W-C, Flögel S, Rüggeberg A. 2008. Cold-water coral growth in relation to the hydrography of the Celtic and Nordic European continental margin.
- Edwards AJ, Head SM. 1987. *Red Sea*. Oxford: Pergamon.
- Gori A, Grover R, Orejas C, Sikorski S, Ferrier-Pagès C. 2014a. Uptake of dissolved free amino acids by four cold-water coral species from the Mediterranean Sea. *Deep Sea Research Part II: Topical Studies in Oceanography* 99:42–50.

- 235 Gori A, Reynaud S, Orejas C, Gili J-M, Ferrier-Pagès C. 2014b. Physiological performance of the
236 cold-water coral *Dendrophyllia cornigera* reveals its preference for temperate
237 environments. *Coral Reefs* 33:665–674.
- 238 Hennige SJ, Wicks LC, Kamenos NA, Bakker DCE, Findlay HS, Dumousseaud C, Roberts JM.
239 2014. Short-term metabolic and growth responses of the cold-water coral *Lophelia*
240 *pertusa* to ocean acidification. *Deep Sea Research Part II: Topical Studies in*
241 *Oceanography* 99:27–35.
- 242 Van der Land J. 2008. UNESCO-IOC Register of marine organisms (URMO).
243 <http://www.marinespecies.org/urmo>. Accessed on 2014-09-08.
- 244 Maier C, Watremez P, Taviani M, Weinbauer MG, Gattuso JP. 2012. Calcification rates and the
245 effect of ocean acidification on Mediterranean cold-water corals. *Proceedings of the*
246 *Royal Society B: Biological Sciences* 279:1716–1723.
- 247 Marenzeller E. 1906. Das Rote Meer, noerdliche und suedliche Haelfte 1895-1898. In: *Berichte*
248 *der Kommission fuer ozeanographische Forschungen*. Expeditionen S.M. Schiff “Pola.”
- 249 Naumann MS, Niggel W, Laforsch C, Glaser C, Wild C. 2009. Coral surface area quantification–
250 evaluation of established techniques by comparison with computer tomography. *Coral*
251 *Reefs* 28:109–117.
- 252 Naumann MS, Orejas C, Ferrier-Pagès C. 2013. High thermal tolerance of two Mediterranean
253 cold-water coral species maintained in aquaria. *Coral Reefs* 32:749–754.
- 254 Naumann MS, Orejas C, Ferrier-Pagès C. 2014. Species-specific physiological response by the
255 cold-water corals *Lophelia pertusa* and *Madrepora oculata* to variations within their
256 natural temperature range. *Deep Sea Research Part II: Topical Studies in Oceanography*
257 99:36–41.

- 258 Naumann MS, Orejas C, Wild C, Ferrier-Pages C. 2011. First evidence for zooplankton feeding
259 sustaining key physiological processes in a scleractinian cold-water coral. *Journal of*
260 *Experimental Biology* 214:3570–3576.
- 261 Orejas C, Ferrier-Pagès C, Reynaud S, Gori A, Beraud E, Tsounis G, Allemand D, Gili J. 2011a.
262 Long-term growth rates of four Mediterranean cold-water coral species maintained in
263 aquaria. *Marine Ecology Progress Series* 429:57–65.
- 264 Orejas C, Ferrier-Pagès C, Reynaud S, Tsounis G, Allemand D, Gili JM. 2011b. Experimental
265 comparison of skeletal growth rates in the cold-water coral *Madrepora oculata* Linnaeus,
266 1758 and three tropical scleractinian corals. *Journal of Experimental Marine Biology and*
267 *Ecology* 405:1–5.
- 268 Qurban MA, Krishnakumar PK, Joydas TV, Manikandan KP, Ashraf TTM, Quadri SI, Wafar M,
269 Qasem A, Cairns SD. 2014. In-situ observation of deep water corals in the northern Red
270 Sea waters of Saudi Arabia. *Deep Sea Research Part I: Oceanographic Research Papers*
271 89:35–43.
- 272 Roberts JM, Wheeler AJ, Freiwald A, Cairns S. 2009. *Cold-Water Corals: The biology and*
273 *geology of deep-sea coral habitats*. Cambridge: University Press.
- 274 Roder C, Berumen ML, Bouwmeester J, Papathanassiou E, Al-Suwailem A, Voolstra CR. 2013.
275 First biological measurements of deep-sea corals from the Red Sea. *Scientific Reports* 3.
- 276 Schneider K, Erez J. 2006. The effect of carbonate chemistry on calcification and photosynthesis
277 in the hermatypic coral *Acropora eurystroma*. *Limnology and Oceanography*:1284–1293.

278 **Figure legends**

279 **Figure 1.** a) Freshly collected *Eguchipsammia fistula* specimen (arrowhead indicates tissue
 280 border); b) Tissue overgrowing PVC substrate in long-term reared *E. fistula* (arrowhead indicates
 281 tissue; black asterix indicates coral glue); c) Polyp proliferation in long-term reared *E. fistula*
 282 (arrowhead indicates newly grown polyp).

283 **Figure 2.** a) Respiration rates (R) and b) Calcification rates (G) of long-term reared and freshly
 284 collected *E. fistula*; mean $\pm$ SD.

Table 1 (on next page)

Table 1.

Environmental conditions of the azooxanthellate coral *E. fistula* in its natural habitat and in captivity (KAUST aquaculture). Values are provided as mean $\pm$ SD.

Table 1. Environmental conditions of the azooxanthellate coral *E. fistula* in its natural habitat and in captivity (KAUST aquaculture). Values are provided as mean $\pm$ SD.

Environmental Parameters	Natural habitat [#]	Aquaculture (KAUST 2013-2014)
T [°C]	21.5	21.3 $\pm$ 0.3 ⁺
Sal [PSU]	40.5	40.5 $\pm$ 0.5 ⁺
pH	8.0 - 8.1	8.11 $\pm$ 0.02*
O ₂ [mg L ⁻¹]	1 - 2	8.67 $\pm$ 0.04 ⁺
TA [μmol kg ⁻¹]	2400 - 2500	2064 $\pm$ 29*
Aragonite saturation Ω	4 - 5	3.06 $\pm$ 0.08*

[#]Values from Roder et al. (2013)

*Measured twice in triplicate in November 2013

⁺Continuous measurements

Table 2 (on next page)

Table 2.

Incubation conditions (start values) and respiration (R) and calcification (G) rates of freshly collected (from onboard incubations) and long-term reared coral *E. fistula* specimens. Values are provided as mean $\pm$ SD.

Table 2. Incubation conditions (start values) and respiration (R) and calcification (G) rates of freshly collected (from onboard incubations) and long-term reared coral *E. fistula* specimens. Values are provided as mean $\pm$ SD.

Parameter	Onboard incubations (60 – 80 min) of freshly collected <i>E. fistula</i> [#]	Lab incubations (24 h) of long-term captive <i>E. fistula</i>
T [°C]	21.0 $\pm$ 0.5	21.8 $\pm$ 0.1
Sal [PSU]	39.150 $\pm$ 0.001	41.1 $\pm$ 0.1
pH	8.2600 $\pm$ 0.0002	8.06 $\pm$ 0.02
O ₂ [mg L ⁻¹]	5.64 $\pm$ 0.06	8.54 $\pm$ 0.05
TA [μmol kg ⁻¹]	2433	1842 $\pm$ 15
Aragonite Saturation Ω	5.45	2.50 $\pm$ 0.07
R [μg O ₂ cm ⁻² h ⁻¹]	3.67 $\pm$ 0.78	1.75 $\pm$ 0.78
G [μmol CaCO ₃ cm ⁻² h ⁻¹]	0.002 $\pm$ 1.740	0.013 $\pm$ 0.010

[#]Values from Roder et al. (2013)

1

Specimens of *E. fistula*

Figure 1. a) Freshly collected *Eguchipsammia fistula* specimen (arrowhead indicates tissue border); b) Tissue overgrowing PVC substrate in long-term reared *E. fistula* (arrowhead indicates tissue; black asterix indicates aquaria glue); c) Polyp proliferation in long-term reared *E. fistula* (arrowhead indicates newly grown polyp).

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Figure 2.

a) Respiration rates (R) and b) Calcification rates (G) of long-term reared and freshly collected *E. fistula*; mean $\pm$ SD.