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Formation, Growth and Photo-acclimation of Colonies of the Hermatypic Coral *Galaxea fascicularis* under Different Light Conditions

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Abstract

Polyp budding, bud growth and photo-acclimation of young colonies of the hermatypic coral *Galaxea fascicularis* (Linnaeus, 1767) were studied in semi-open aquaria at the Marine Biological Sesoko Station in Japan. Coral colonies were collected in July 1995 (for experiment 1) and in September 1997 (for experiment 2) at a depth of 2 m from well-lighted sites in the East China Sea near Sesoko Island, Okinawa. Formation of new colonies from detached polyps were investigated by maintaining the polyps in different light regimes (95%, 30%, 15%, and 5% PAR_0). Young colonies that grew under 30% PAR_0 were acclimated to light intensities of 95% and 8% PAR_0 during a subsequent 120 days. Then the morphophysiological characteristics of polyps, buds and young colonies studied were the number of buds on the polyp, average length and diameter of the buds formed on the polyp, number of healthy-looking symbiotic dinoflagellates (SD) per unit square of polyp and buds, SD volume, chlorophyll concentration in SD, the rate of maximum gross photosynthesis of SD, levels of proliferous SD frequency (PSDF) and degrading SD frequency (DSDF) of the parent polyp and young colony and the growth rate of

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young colonies of *G. fascicularis*. The majority of these measurements was conducted on dynamics of photo-acclimation. The investigations showed that detached individual polyps from the parent colonies of *G. fascicularis* were capable of forming buds under light intensities from 95% to 15% PAR_0. Shade stimulated bud formation and bright light promoted their growth. Two morphophysiological types of SD were found in the parent polyps and in new colonies of *G. fascicularis*: type G (green) displayed tolerance to bright light and type B (brown) – to shade. Photo-acclimation of young colonies of *G. fascicularis* to lowered light intensity occurred by increasing the SD population density, the relative number of the shade-tolerant type and the chlorophyll concentration in SD. Under increased light intensities SD population density and chlorophyll concentration in the algae decreased and the relative number of the light-tolerant type increased.

Keywords: *Galaxea fascicularis*, hermatypic coral, symbiosis, symbiotic dinoflagellates, zooxanthellae, buds, growth, photo-acclimation

1. Introduction

Scleractinian corals of the genus *Galaxea* form colonies from corallites weakly-linked with each other (Veron, 1986). Colonies of the species *Galaxea fascicularis* can be broken easily by slight touch, breaking up into separate polyps especially at the sites visited by people. An individual polyp detached from the parent colony, may under certain conditions, form buds and then develop into new colonies. However, in the field, the destroyed colonies of *G. fascicularis* mostly die, probably, because the polyps released from colonies are gnawed by fish, or are covered with silt, or are exposed to wave action or extreme light conditions (deficiency or surplus). In order to find the conditions necessary for forming new colonies of *G. fascicularis* experiments established were under aquaria conditions with individual (released) corallites. It was important to elucidate the light intensity necessary for colonies formation. It is known that colonies of the coral *G. fascicularis* dwell in a wide range of light intensity, at least from 90% to 2% of incident photosynthetically active radiation (PAR_0) (Titlyanov and Latypov, 1991). However, that does not mean that polyps detached from the parent colony can adapt to such a wide light range, to form buds and thereafter develop into new colonies. The age of the colony branches determines the physiological state of different parts of a colony and consequently their photo-acclimation capacity (e.g., Titlyanov, 1991; Titlyanov et al., 1988a). It is possible that individual polyps, buds, young and adult colonies have different adaptation capacities. Some adaptive reactions to both bright and low light and light ranges of the realization of these reactions are known for adult colonies of some coral species (Falkowski

and Dubinsky, 1981; Rowan and Knowlton, 1995; Rowan et al., 1997; Titlyanov et al., 2000, 2001). Light adaptive capacities of species of the genus *Galaxea* were not studied so far.

Thus, the aim of the present investigation was 1) to study the most suitable light conditions for the process of budding of polyps detached from the parent colonies of *G. fascicularis* and growth and development of new colonies; 2) to elucidate reactions of adaptation to bright and low light in buds and in new colonies formed from individual polyps.

2. Materials and Methods

Biological material

Colonies (20–30 cm diam.) of the coral *Galaxea fascicularis* (Linnaeus, 1767) were collected in July 1995 (for experiment 1) and in September 1997 (for experiment 2) at a depth of 2 m in the East China Sea near the Sesoko Marine Station, Tropical Biosphere Research Centre, University of the Ryukyus, Okinawa, Japan. The colonies were placed in plastic bags with seawater and transported to a 6 m^3 semi-open aquarium supplied with seawater (turnover rate 5% h^{-1} in 1995 and 30% h^{-1} in 1997) and left there until used. A black plastic net shaded the aquarium and the light intensity amounted to 30% of incident photosynthetically active radiation (PAR_0). In both experiments the colonies were kept in semi-open aquaria for 30 days. After that, each colony was carefully separated into individual polyps by hand. The corallites of 4–5 cm length (with skeleton area partly covered by about 400–600 mm^2 living tissue) were fixed with cement onto ceramic tiles (Fig. 2a) and returned to the aquarium for 3–6 days before experiments began.

Experimental design

Experiment 1

Individual polyps released from the colony and fixed onto ceramic tiles were exposed to different light conditions 95%, 30%, 15% and 5% PAR_0 in the same aquarium. Incident light was reduced using gray and black plastic mesh, the light intensity 95% PAR_0 in the aquarium was achieved by exposure to the open sun. The temperature in the aquarium was 26–29°C in the daytime and 25–27°C at night. The corals were maintained under intense aeration for 60 days. On the 15th, 30th and 60th day of the experiment three polyps or new colonies from each light treatment were analysed to determine the number of buds formed, number of symbiotic dinoflagellates (SD), and chlorophyll concentration in SD. Polyps maintained under light intensity 5% PAR_0 were not analysed because

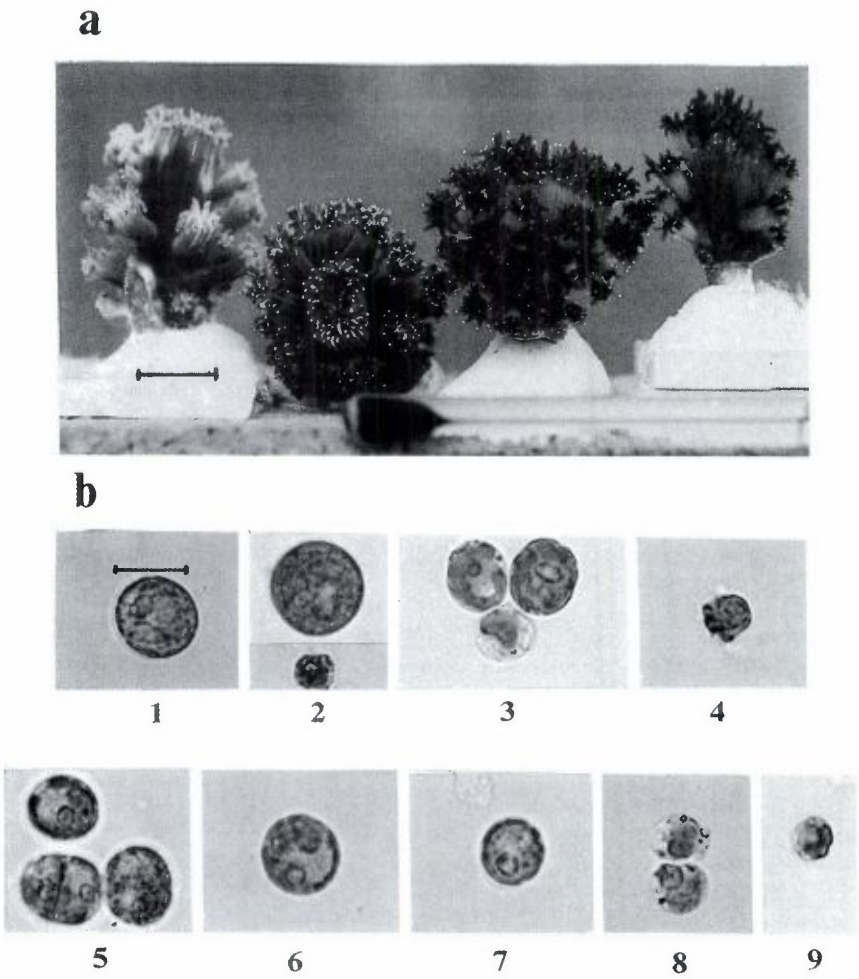


Figure 1. (a) Young colonies of the coral *Galaxea fascicularis* which grew under light intensities (from left to right) 95%, 30%, 8% and 6% PAR_0 during 120 days; bar = 1 cm; (b) two different types of SD found together in the living tissue of the coral *G. fascicularis*. Magnification ×1000. 1 – SD of type B; 2 (upper) – SD of type B; (lower) – degraded SD particles (DSDP) of the type B; 3 – three SD of the type B in the process of degradation; 4 – DSDP of the type B; 5 – SD of the type G (one dividing cell); 6 and 7 – SD of the type G; 8 – two SD of the type G in the process of degradation; 9 – DSDP of the type G; bar = 10 μm.

they did not form buds. On the 60th day of the experiment formed buds were carefully detached from the parent polyp with a scalpel. Number of SD, photosynthetic rate, indices of SD division and degradation were determined

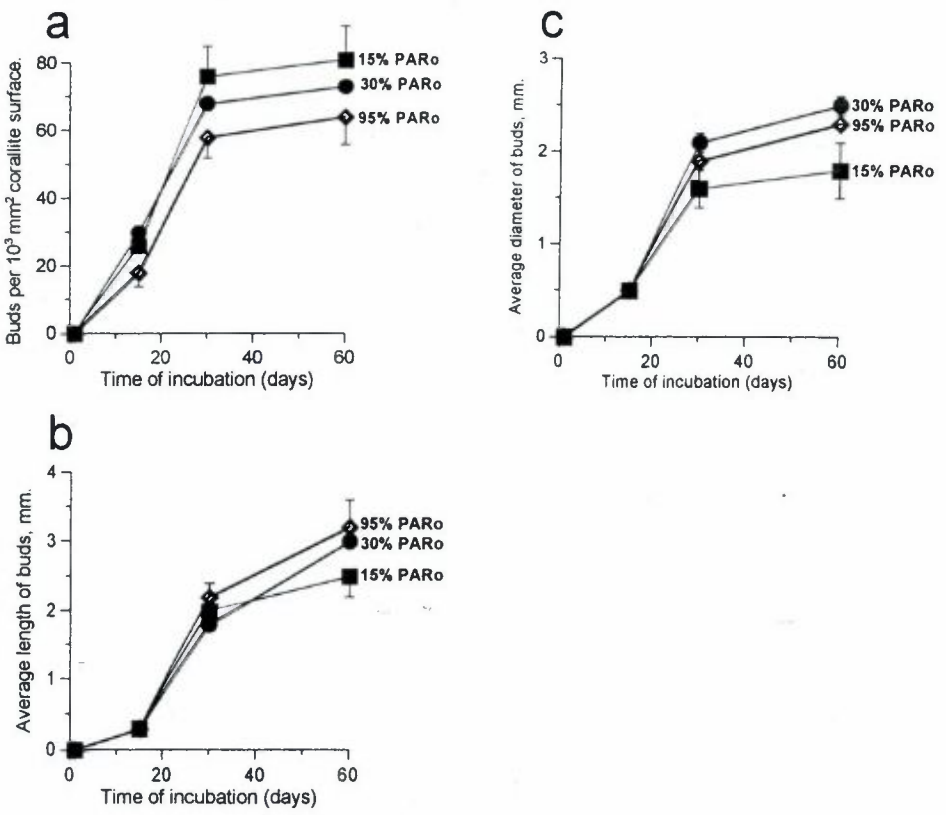


Figure 2. Changes in number (a), in average length (b) and in average diameter (c) of buds (d) that formed and grew on the parent polyp of the coral *G. fascicularis* under various light regimes.

for detached buds. Three parent polyps from three different colonies were used in each analysis. Means and standard deviations were calculated from three parent polyps (n=3).

Experiment 2

The polyps were maintained in a semi-open aquarium under 30% PAR_0 with temperature 25–27°C in the daytime and 23–24°C at night under intense aeration for 40 days (October – beginning November). During this period new buds were formed on the sides of the parent polyps, developed into new colonies, grew well and acclimated to 30% PAR_0. After this treatment these colonies were exposed to different light conditions: 95%, 30% and 8% PAR_0 for 120 days. The temperature in the aquaria to the end of the experiment (in

February) was 22–24°C in the daytime and 20–22°C at night. Three new colonies formed on the parent polyps from three different colonies were used in each light variant to determine their physiological state.

Counting of newly formed buds and their measurement

The number of new buds was calculated for each polyp and normalized per 10^3 mm^2 of the corallite area covered by the living tissue. Length and external diameter of an individual corallite of each bud were measured with a ruler. The surface area of the parent corallite and buds formed (on the 60th day of the experiment) was measured by wrapping with thin aluminium foil and the area calculated according to Marsh (1970). Using a magnifying glass (×2) and owing to a skill, the error of the method was no more 5% for the parent corallites and no more 10% for buds with average sizes (3 mm in length and 2 mm in diameter).

Removal of coral tissue and analyses of the number of symbiotic dinoflagellates (SD), proliferating SD frequency (PSDF), degrading SD frequency (DSDF) and diameters of algal cells

Living coral tissue was removed with a Water-Pik (Johannes and Wiebe, 1970). Small sub-samples of the tissue homogenate were analysed using a hemocytometer for estimations of zooxanthellae densities, PSDF, DSDF and algal diameters. Ten to twelve replicate sub-samples were measured. Counts were made of healthy-looking symbiotic dinoflagellates (HSD) and dividing and degrading SD. Cells were classified as dividing if they showed the initial appearance of a division furrow in the mother cells, to the formation of cell envelopes in daughter cells. Degrading cells were identified by colour, size and shape after Titlyanov et al. (1996). A total of 500 to 1000 cells was counted in each sample and the percentage of algal cells dividing was classified as the PSDF and the percentage of algal cells degrading was classified as the DSDF. These estimates were undertaken at 9:00–11:00 h when the number of dividing cells amounted to 80% of the maximum and degraded zooxanthellae numbers were highest (Titlyanov et al., 1996). The diameters of one hundred HSD were measured from each sample using a calibrated ocular micrometer at 400× magnification.

Chlorophyll concentrations

To determine chlorophyll concentrations a known number of SD were filtered under vacuum (AP Millepore filters) and placed (together with a filter) in a refrigerator for two days in an aqueous solution of 90% acetone. The solution with sample was shaken daily. The absorbance of acetone extracts was measured at 630 and 663 nm using a Hitachi U-2000 spectrophotometer. The

concentrations of chlorophyll *a* and chlorophyll c_2 were determined using the spectrophotometric equations of Jeffrey and Humphrey (1975). Chlorophyll concentrations were expressed as μg per mm^3 of the zooxanthellae volume.

Measurement of photosynthetic and dark respiration rates

Photosynthetic capacities and the respiration rates are the most important characteristics for estimation of the physiological state of SD, polyps and buds. The rates of net O_2 production and O_2 consumption were measured for the coral branches according to Leletkin et al. (1996). The oxygen flux was measured using a respirometer consisting of a cylindrical glass chamber (400 ml volume) with a Clark oxygen electrode (OYI 53010 Model) coupled to a chart recorder and magnetic stirrer. Polyps, new colonies or detached buds from the parent polyps were set on a plastic net in seawater at a distance of 3 cm from a magnetic stirring bar. The chamber was blocked off with a stopper that prevented any exchange with the atmosphere. Temperature was maintained at 25±0.5°C with a circulating water bath. A halogen lamp (150 W) was used for illumination and PAR was selected through a thermal filter (with 2% $CaSO_4$ solution). Light intensity was measured with a Li-Cor radiation sensor (Model Li-192 SB). Quantum flow of PAR in the respirometer, equaled 1300 μE cm^{-2} s^{-1}. The O_2 electrode was calibrated before each measurement according to Green and Carritt (1967). Polyps, new colonies and individual buds were exposed to light for 30 minutes. Dark exposure was 60 minutes.

Growth rate

After two months of acclimation of young *G. fascicularis* colonies to 95%, 30%, 8% and 6% PAR_0 in experiment 2, some samples were detached from the ceramic tiles, shaken to remove excess water and weighed. These samples were maintained for 30–40 days under the same light intensities and re-weighed again. The growth rate of samples was calculated using the formula:

$$\mu = \frac{m_1 - m_0}{m_0 \times \Delta T} \times 100$$

where m_0 is initial weight; m_1 is a weight at the end of the experiment, ΔT is the time between the two measurements of weight, μ is the average growth rate measured in mg × g^{-1} × day^{-1} (Brinkhuis, 1985). It is necessary to note that the error of the method is rather significant and reached to about 10% for the same polyp of *G. fascicularis* (by 5 replicate weighings).

Statistical analysis

A Student's t-test was used to analyse the data and to evaluate differences between means. The difference between means with $p<0.05$ was considered significant.

3. Results

Experiment 1

On the 8–10th day of the experiment new buds began to form on the sides of the parent polyps in light variants of 95%, 30% and 15% PAR_0. In variant 5% PAR_0 buds were not formed during 60 days of the treatment. The formation of buds occurred mostly within the period of 10–40 days of the experiment. Changes in the bud numbers from the 30th to the 60th days were insignificant (Fig. 2a). The greatest number of the buds (more than 80) per 10^3 mm^2 of surface of the parent polyp was formed in light variant 15% PAR_0, the least (about 60 buds) was in bright light (95% PAR_0). In the treatments 15% and 30% PAR_0 the differences in the bud numbers were insignificant (Fig. 2a). The largest buds (3.5 mm length and more than 2 mm in diameter) were formed in bright light. The differences in diameters and in lengths of the buds in light variants 15% and 95% PAR_0 were significant ($p<0.05$). At the same time, in light variants 30% and 95% PAR_0 these differences were insignificant (Figs. 2b, c).

The number HSD in a new colony formed on the parent polyp gradually increased with buds growing (Fig. 3a) and at the end of the experiment it was greatest under low light (15% PAR_0). The least HSD numbers were under bright light (95% PAR_0). HSD densities under moderate light (30% PAR_0) differed insignificantly from that of under low light (Fig. 3a). The largest HSD volume was under 95% PAR_0 on the 30th day of the experiment, the least HSD volume was under 15% PAR_0 (Fig. 3b). Chlorophyll concentration calculated per volume of SD differed significantly on the 15th day of the experiment: it was higher in low light than in bright light and at the end of the experiment the difference increased 1.5-fold (Fig. 3c). P^{max}_{gross} values of SD cells differed significantly ($p=0.032$) in variants with low and bright light on the 30th day of the experiment. Photosynthetic capacities of SD in bright light were two times higher than in low light (Fig. 3d). Difference in photosynthetic intensity of SD from dim and low light was insignificant. The intensity of SD division (PSDF) in low and moderate light grew 1.5 to 2 times on the 15th day of the experiment and this index was higher during the consequent days of the experiment and only near to the end of the experiment the PSDF was equal in all light variants (Fig. 3e). The intensity of SD degradation (DSDF index) significantly dropped

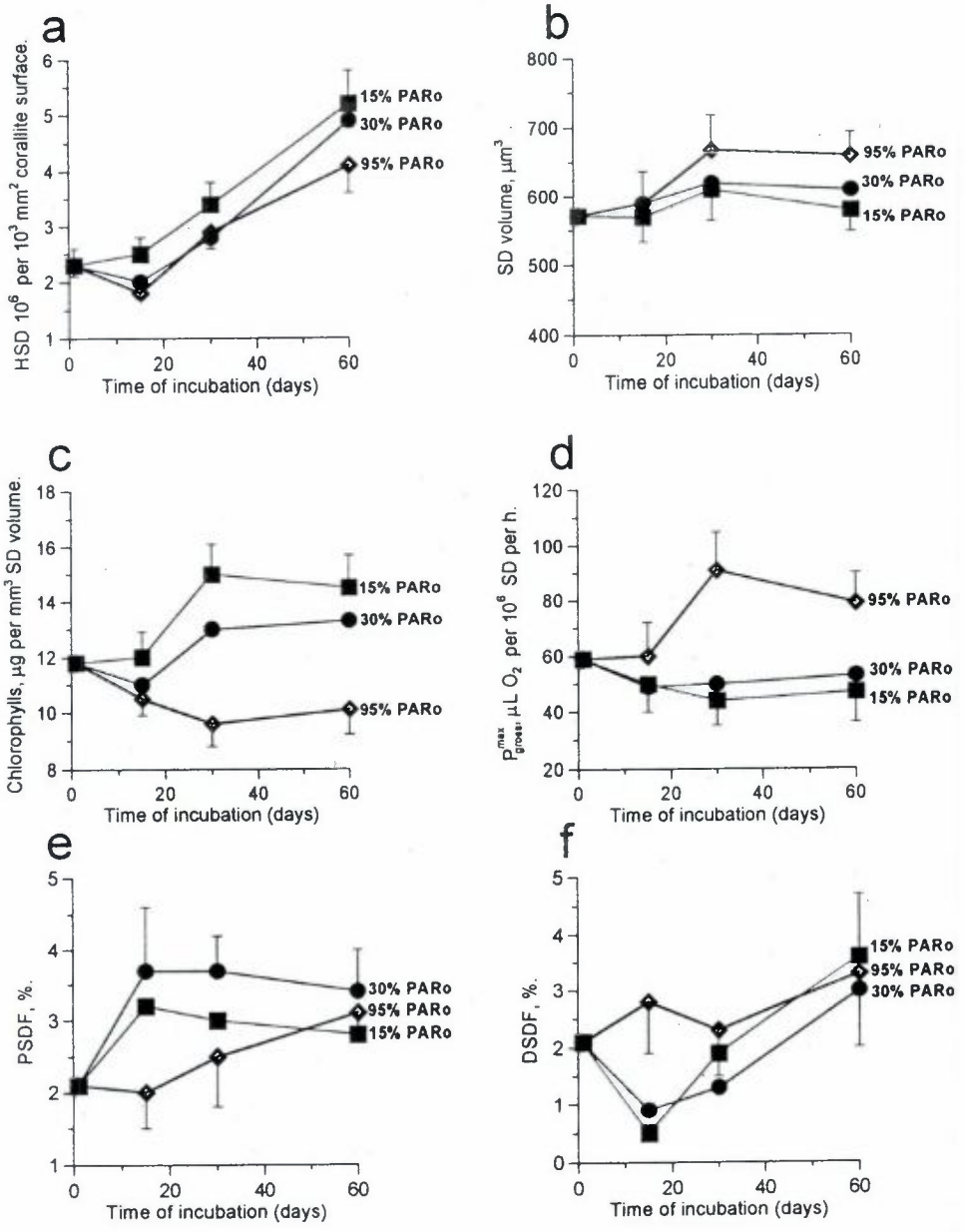


Figure 3. Changes in number of healthy-looking symbiotic dinoflagellates (HSD) per unit of surface area of corallite (a), in volume of HSD (b), in chlorophyll concentration of SD (c), in the rate of maximum gross photosynthesis per 10^6 SD (d), in the levels of proliferous SD frequency (e), and degrading SD frequency (f) of the parent polyp and new colony of *G. fascicularis* during 60 days of maintenance under various light intensities.

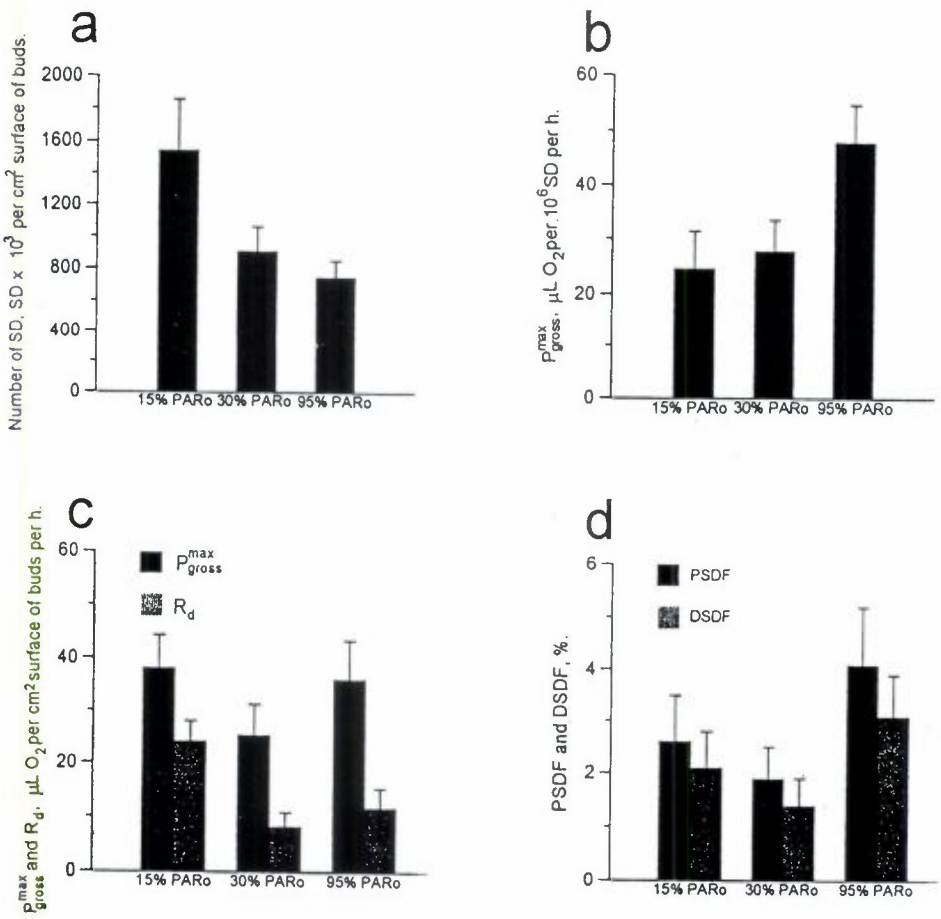


Figure 4. SD population density (a), the rate P^{max}_{gross} and R_d per cm2 of surface area of buds (c), PSDF and DSDF levels (d) of new buds of the coral *Galaxea fascicularis* growing under different light intensities during 60 days (experiment 1) and then detached from the parent polyps for analyses.

in low (p=0.041) and moderate (p=0.033) light on the 15th day of the experiment, however, it increased the following days and to the end of the experiment slightly differed in initial variant and in bright light (Fig. 3f).

In Fig. 4 are given some physiological characteristics for buds detached (by hand) from the parent polyps and their SD on the 60th day of the experiment. The formed buds, that grew and adapted to 15% PAR_0, showed a higher SD density in comparison with SD from 30% PAR_0 (p=0.024) and 95% PAR_0

($p=0.019$) (Fig. 4a). However, photosynthetic capacities of HSD adapted to low light were two-fold lower than in HSD that grew in bright light (Fig. 4b). The rate of maximum gross photosynthesis of buds calculated per cm^2 of their surface in all three variants differed insignificantly (Fig. 4c). At the same time the rate of dark respiration of the buds was highest in the variant with low light (Fig. 4c). PSDF and DSDF levels in low and moderate light differed insignificantly, however, the levels were considerably lower than in bright light (Fig. 4d). In all light regimes the ratio of the PSDF and DSDF was more than 1.

Experiment 2

Young *G. fascicularis* colonies that grew under different light intensities (during 120 days) differed significantly by colour (Fig. 1a). The colonies maintained under bright light (95% PAR_0) were golden-brown, brown under moderate (30% PAR_0) and dark-brown under low light (8% and 6% PAR_0). Both the parent and the new colonies of *G. fascicularis* contained two morphophysiological types of SD, well-differed by colour and size. These types were called type B (brown) and type G (green) (Fig. 1b). Cells of type B were larger than type G, with diameters varying from 8 to 14 μm (Fig. 1b). The algae of type B were spherical with a golden-brown colour. Degraded particles of SD (DSDP) of type B were of irregular shape and a light-brown colour. The average diameter of degraded cells was 5.7 μm. Accumulation bodies were pale, yellowish and were the primary constituent of the DSDP. The cells of the type G were smaller, their sizes varied from 7 to 11 μm (Fig. 1b) and they were different from SD of type B in that they were shaped as spheres or bean-shaped cells and had an olive-green colour. Sizes of degraded particles of SD of the G type were also smaller in average 4.2 μm. The G type SD had well-visible accumulation bodies and pyrenoids with a bluish starch sheath. These features were identified by colour and size under the microscope (×400) in homogenates after removal of the living tissue with a Water-Pik.

Continuous (160 days) experiments on the formation and growth of new colonies of *G. fascicularis* showed that the bud formation on the parent polyp under 30% PAR_0 begun on the 8th to 10th day of the experiment and finished on the 40th to 60th day. These young colonies continued to grow within 100 subsequent days (Fig. 5) but did not give new buds (Fig. 6a). The growth rate of the colonies was about 4 mg per g of fresh weight per day under bright (95%) and moderate (30%) light. In low light (8% and 6% PAR_0) colonies also grew, but with the rate two times lower ($p<0.05$) than in bright light (Fig. 5). Lengths and diameters of new polyps increased in both bright and low light and at the end of the experiment there were no significant differences in the dimensions of new polyps that grew under bright and low light (Fig. 6b). During 120 days of the experiment the HSD population densities increased (in

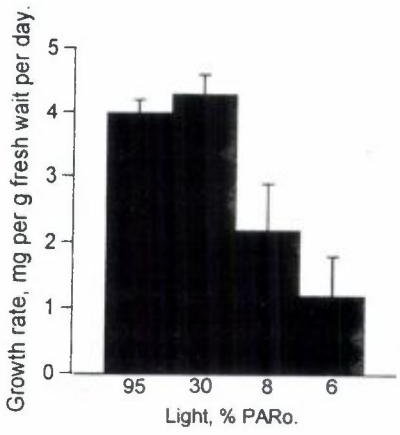


Figure 5. The growth rate of new colonies of the coral *G. fascicularis* acclimated to the light intensities 95%, 30%, 8% and 6% PAR_0.

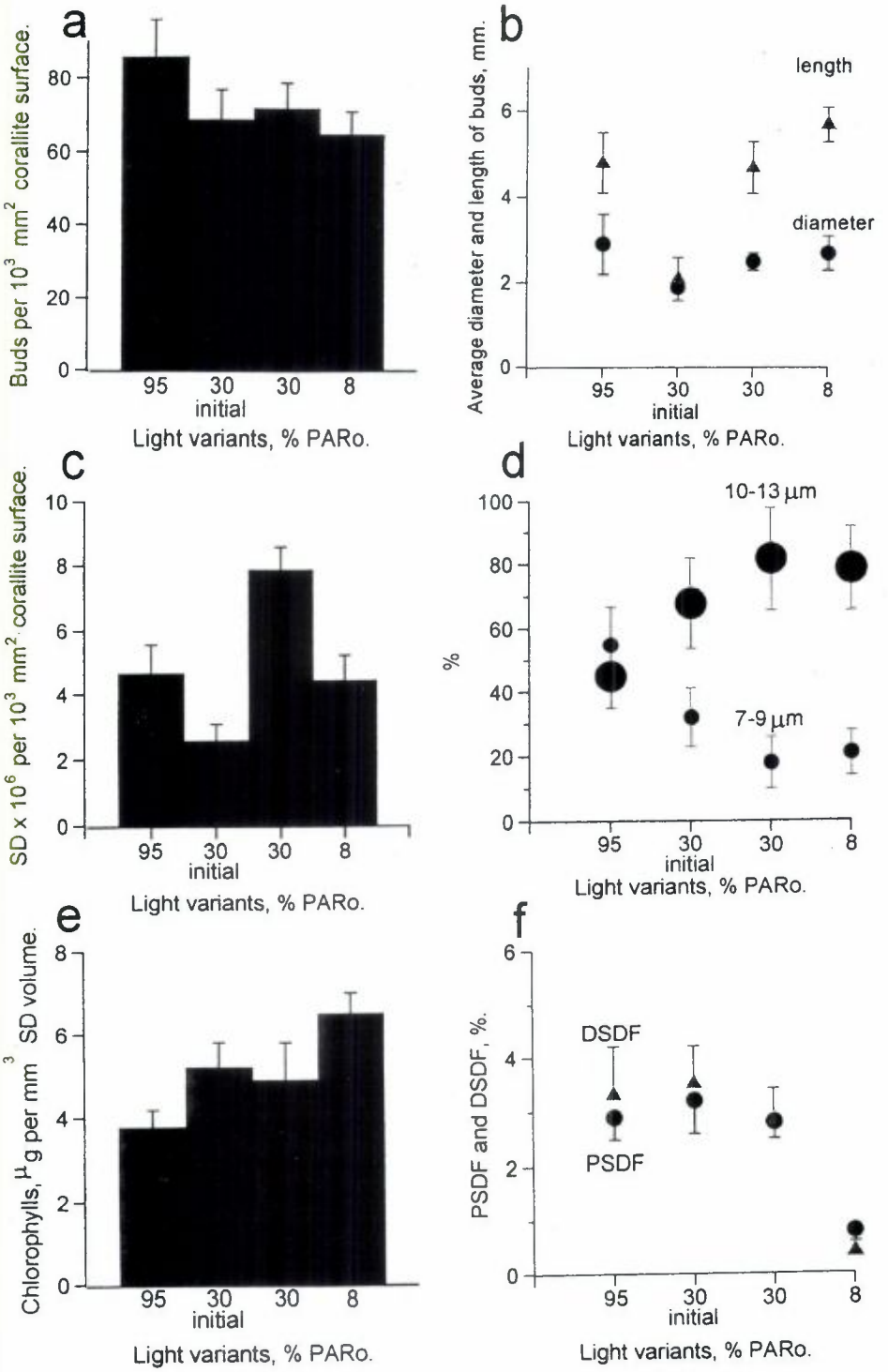
comparison with initial) significantly two-fold in bright and low light and three-fold in moderate light (Fig. 6c). In bright light the population of small (7–9 μm) SD increased significantly and the population of the larger (10–13 μm) SD dropped. Opposite changes were observed in moderate and low light ($p<0.05$) (Fig. 6d). Chlorophyll concentration calculated per volume of SD dropped considerably under bright light and increased significantly ($p<0.05$) under low light (Fig. 6e). PSDF and DSDF levels did not change significantly in bright and moderate light but dropped 3–4-fold in low light (Fig. 6f). The ratio PSDF to DSDF was about 1 in all light regimes of the experiment.

4. Discussion

As a result of the experiments conducted it was shown that corals of *G. fascicularis* are capable of colony formation by budding on the parent (detached) polyps in the light range from 95% to 15% PAR_0. Under light intensity 5% PAR_0 the corals did not form buds, although, corals of *G. fascicularis* dwelled under this light intensity (Titlyanov and Latypov, 1991) and we found that young colonies of *G. fascicularis* are capable of acclimation to considerably low light – 0.8% PAR_0 (Titlyanov, unpublished data). Probably, the light intensity 5% PAR_0 was not enough for the budding process. Bud formation on the parent polyps began at the 8th to 12th day after detachment of the polyps from colonies and after exposure to light. Bud formation lasted till 40 to 60 days of maintenance. In bright (95% PAR_0) the

number of formed buds was the least compared to bud numbers in moderate light, but the buds (in bright light) were capable of rapid growth and on the 60th day of the experiment total area equalled under bright and moderate light. In low light, bud growth was slower. Large SD with high photosynthetic capacities were accumulated in the buds that grew under bright light and small SD with low photosynthetic capacities accumulated under low light. At the same time, SD concentration in buds from low light was considerably higher than that of buds from bright light. As a result of this: the photosynthetic capacities of surface unit of the buds that grew under different light conditions were equal. In addition, chlorophyll concentration in SD of the buds growing under low light was two times higher than in that of the buds in bright light, that gives them the advantage of light-harvesting and effective utilization of low light (Zvalinsky, 1988). The equalization of photosynthetic capacities calculated per surface area unit of buds that grew under different light intensities probably indicates complete photo-acclimation of young colonies of *G. fascicularis* to bright, to moderate and to low light. Equal photosynthetic capacities in adult colonies of the coral *Stylophora pistillata, Pocillopora damicornis* and *P. verrucosa* were found in the field under light from 95% to 20% PAR_0, in the South China Sea (Cherbadgy and Pham Van Hyuen, 1988; Titlyanov et al., 1988b). The other important adaptive reaction to light of young colonies *G. fascicularis* was accumulation of chlorophylls in SD with reducing light intensity and their loss with increasing light intensity. This widespread reaction was found in adult colonies for many species of hermatypic corals (e.g., Falkowski and Dubinsky, 1981; Dustan, 1982; Porter et al., 1984; Titlyanov et al., 2000, 2001). In this experiment, stable level of pigments in SD became established on the 30th day of maintenance. PSDF and DSDF levels in buds of new colonies of the coral *G. fascicularis* maintained under bright light were two times higher than under moderate (30% PAR_0) light, that probably, was a result of higher metabolic activity of corals living in bright light.

In experiments of 1997 two morphophysiological types of SD were found in adult and in young colonies of the coral *G. fascicularis* sampled near Sesoko Island (type B of brown colour, regular spherical shape, 8–14 μm in diameter and type G an olive-green colour, mostly irregular spherical shape, 7–11 μm in diameter). These types were also found in other scleractinian corals, living near Sesoko Island (Titlyanov, unpublished data). *Pocillopora damicornis* contained only type B of SD, only type G were found in *Seriatopora caliendrum* and *S. hystrix*, and both types B and G were found together in *Stylophora pistillata* and *Echinopora lamellosa*. SD of the types B and G differed not only by colour, dimensions and shape but also differed in photosynthetic capacities, primary production, pigment accumulation and maximum rates of cell division and degradation. The analysis of fatty acid composition in lipids also showed


a
Buds per 10^3 mm^2 corallite surface.
0
20
40
60
80
95 30 30 8
initial
Light variants, % PARo.
b
Average diameter and length of buds, mm.
length
diameter
0
2
4
6
95 30 30 8
initial
Light variants, % PARo.
c
SD x 10^6 per 10^3 mm^2 corallite surface.
0
2
4
6
8
10
95 30 30 8
initial
Light variants, % PARo.
d
%
10-13 μm
7-9 μm
0
20
40
60
80
100
95 30 30 8
initial
Light variants, % PARo.
e
Chlorophylls, μg per mm^3 SD volume.
0
2
4
6
8
95 30 30 8
initial
Light variants, % PARo.
f
PSDF and DSDF, %.
DSDF
PSDF
0
2
4
6
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initial
Light variants, % PARo.

differences between these types of SD. On the basis of these morphological, physiological and biochemical differences the conclusion was made: B and G types of SD differed genotypically. The existence of a mixture of different taxons of SD in coral species from Caribbean was shown for the first time by Rowan and Powers in 1991 using RFLP analysis. Later it was also shown by Rowan and by other authors for corals in other regions from the Caribbean (Baker and Rowan, 1997; Baker et al., 1997; Wilcox, 1998).

Experiments in 1997 on adaptation of new colonies of the coral *G. fascicularis* confirmed the data of 1995 that bud forming on the parent polyp took about 1 month. Young colonis *G. fascicularis* maintained under bright (95% PAR_0) and moderate light (30% PAR_0) during 120 days practically did not differ in morphology (lenghts, diameters of new polyps) and in metabolic activity (PSDF and DSDF levels). Photo-acclimation of new colonies of the coral *G. fascicularis* to low light (8% PAR_0) occurred with reducing PSDF and DSDF levels (three-fold lower) compared to bright and moderate light. The acclimation of young colonies to moderate and low light also occurred through an increase in SD density in the tissue and pigment concentration in SD. During long-term photo-acclimation ratios of B and G types of SD were also changed. The relative accumulation of small green algae of the type G occured under photo-acclimation to bright light. The relative number of large, brown algae of the type B increased under adaptation to low and especially to moderate light. That was also found by us in previous investigations for adult colonies of the corals *S. pistillata* and *Echinopora lamellosa* containing the mixture of B and G types of SD (Titlyanov et al., unpublished data). The type G of SD did not accumulate high pigment concentration but was more productive and light-tolerant. At the same time, type B accumulated more pigments than type G and displayed the feature of shade-tolerance. The possibility to form certain composition of populations of genetically determined SD types in the corals *Montastrea annularis* and *M. faveolata* in dependence on incident irradiance in habitat (or even different parts of the same colony) was shown in previous papers by Rowan and Knowlton (1995) and by Rowan with coauthors (1997).

See previous page.

Figure 6. Number of buds (a), the average diameter (b), and length of buds (b), SD population density (c), relative number of large (10–13 μm in diameter) and small (7–9 μm in diameter) cells of HSD (d), chlorophyll concentration per mm^3 of SD volume (e) and levels PSDF and DSDF in new colonies of *G. fascicularis* maintained under light 95%, 30% and 8% PAR_0 during 120 days.

5. Conclusion

- Individual polyps of the coral *G. fascicularis* detached from colonies and placed in aquarium were able to form buds on the sides of the parent polyps under light intensities from 95% to 15% PAR_0.
- Budding began on day 8 to 12 and ended on day 30 to 40 of the exposure to light.
- Moderate and low light stimulated budding, bright light promoted growth of new polyps.
- Young *G. fascicularis* colonies adapted to light intensity of 95% and 30% PAR_0 had similar rates of growth and metabolic activities. Under adaptation to low light (8% PAR_0) the growth rates and metabolic activity in young colonies declined.
- Young *G. fascicularis* colonies were photo-acclimated by changes in chlorophyll concentration of SD, in SD population density in polyp tissue and in relative content of two different types of algal symbionts.
- The obtained data could be useful for cultivation of colonies of the coral *Stylophora pistillata* from individual polyps and for restoring degraded reefs.

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