The reticulated chloroplasts of zooxanthellae (*Symbiodinium*) and differences in chlorophyll localization among life cycle stages

Received: 17 March 2010 / Accepted: 30 April 2010 / Published online: 22 May 2010
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Fig. 1 Panel **a** A micrograph depicting the smooth reticulated and condensed-punctated chloroplast morphology exhibited by different *Symbiodinium* life stages (imaged by confocal laser scanning of chlorophyll fluorescence excited at 488 nm). Panel **b** provides individual examples of the major cell stages including a *i* coccoid cell (the dominant stage seen inside the host) *ii* dividing doublet and *iii* tetrad cells, and *iv* the motile mastigote (scale bar 5 μm). Images are viewed best using 3-D glasses

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Reef sites

Coral Reefs (2010) 29:627
DOI 10.1007/s00338-010-0635-0

Animal–microbe symbioses are the foundation of coral reef ecosystems. These associations are highly effective solar energy collectors, and they photosynthesize at efficiencies many times greater than that of the leaves of terrestrial plants (Enríquez et al. 2005). Reconstructions of the symbiont's ultrastructure show that each symbiont cell typically possesses a single 'lobulate' chloroplast occupying 18–36% of the cytoplasmic volume (Trench and Blank 1987; Blank and Huss 1989). Recent confocal imaging of chlorophyll fluorescence, conducted on isolates of *Symbiodinium* spp. cultured from various host taxa, usually revealed extensive reticulation in plastid morphology. One fortuitous image shown here (Fig. 1a, b) displayed each of the major life history stages, identified initially with light microscopy, that are exhibited by these dinoflagellates. This particular symbiont is a member of Clade A, a group that is ancestral to all other *Symbiodinium* lineages. The punctated chloroplast structure of dividing cells matches more closely to that of the smaller biflagellate motile phase and supports previous indications that *Symbiodinium* usually undergo cell division before they become motile (Fig. 1b; Fitt and Trench 1983). Located around the entire cell periphery, the encircling mesh-like plastid of coccoid cells is positioned to receive photons from any direction. This morphological adaptation (or exaptation, Gould and Vrba 1982) may help in maximizing light-absorption efficiency *in hospite* where complex light fields are generated by multiple scattering of the coral's skeleton (Enríquez et al. 2005).

Acknowledgments The authors thank Mark A. Farmer at the Center for Advanced Ultrastructural Research (UGA) for guidance and assistance. This work was supported by the National Science Foundation.

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