

Interactive comment on “Characterizing photosymbiosis in modern planktonic foraminifera” by Haruka Takagi et al.

Ralf Schiebel (Referee)

ralf.schiebel@mpic.de

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With great pleasure, I have read the manuscript of Takagi and coauthors on “Characterizing photosymbiosis in modern planktonic foraminifera”. The methods and data presented in the paper are a major step forward to better understand photosymbiosis in foraminifera. The table on the presence and absence of photosymbionts and their activity very useful. However, I believe that quantification of the symbiont activity needs to be done under more controlled conditions, and may not be reproducible as it stands now. For examples, when being harbored at the outside of the test, the symbionts may show more activity in FRRf analyses than at an inside position of the foraminifer test. As correctly stated in the manuscript, the taxonomy of the symbionts would need to be clarified. To my impression, the manuscript is publishable when the interpretation

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is tuned down to avoid overinterpretation. In the following, I suggest some changes to the manuscript before publication.

Line 21: The author have possibly not observed “symbiont growth”, and rewording to “symbiont abundance” may be more correct. Line 29: Following the paper of Jakob et al. (2017), planktic foraminifer shells may be composed of vaterite and other calcium carbonate species, and “calcareous” may be the correct term. Line 46: *Globigerina bulloides* has certainly not been reported photosymbiotic. Please delete from the list. Line 48: Change *hirsta* to *hirsuta* Line 50: Change “in all previous studies” to “in some previous studies”. Line 150: Change “in his study” to “in her study”. Lines 182-183: Please delete the sentence “Therefore, although genetic information and detailed microscopic evidence are needed in the future, we categorize them here as dinoflagellate-bearing species.” Second guess does not improve the quality of a scientific, and there is no need to do so in this place. Line 201: Please replace by “ σ PSII was relatively clearly low in dinoflagellate-bearing species. . .” Line 203: Chapter “3.4 Principal component analysis and clustering” would need a brief introduction. Please first write what you tested, i.e. objects and variables, and then present data. In general, this paragraph needs to be better explained and better organized for easy understanding.

In the Discussion and Conclusions chapters, the writing style deteriorates, and some rewording would be necessary. I would recommend using the present tense throughout, since it makes a nicer reading.

Lines 230-231: “Based on the result of the PCA and cluster analyses, 30 foraminiferal species were characterized and categorized into four groups (Fig. 9).” This not correct; Statistics cannot create new results, but confirm results. Please rewrite the sentence accordingly. Lines 241-242: Please rephrase to “Though our study did not identify their genotype, we revealed that this species never possessed symbionts even when collected from shallower water depth (< 100m).” Line 242: “A recent study. . .” Line 248: “Five species were newly confirmed as symbiotic in this study;. . .” Line 249 ff: “All species in the Cluster 1 and 2 including. . .”. Since we are not primarily inter-

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ested in Clusters by different groups of foraminifera, you may name these groups for a better understanding. "All species in the macroperforate spinose group with dinoflagellate symbionts, and the macroperforate spinose foraminifera with non-dinoflagellate symbionts..." reads much better, because it contains important information. Please change all of the following text accordingly. Line 253: delete "itself" Line 254: replace "directly clarified" by "determined" Line 255: replace "growth" by "size" Line 256: replace "should be a specific diagnostic of" by "may indicate" Line 257: replace "perform" by "support" Line 258-259: delete "It may imply more phototrophic nature of these species.", since this is second guess Line 264: please say which species sometimes found without symbionts Line 267: "We speculate that these small specimens were..." Line 268: "...symbiont-barren individuals in this group was small." Line 273: "...on phototrophy that can quantitatively represent photosymbiosis." Line 277-278: "...the examined species were not able to increase their biomass as the host grew." How do you know? This is possibly second guess, and should be deleted from the manuscript. Please delete also the following argumentation "If these are the case, possession of symbionts...". Line 293-294: "However, caution should be paid for the narrow size range of *T. humilis* (97–168 μm) (Fig. 6)." This is possibly also the case for *T. humilis* smaller than 97 microns. Line 304: delete "utter" Line 304: "Each foraminiferal species..." I doubt that this is the case for each species; please see your Fig. 11. Line 308: "...various families..." Please explain. Which genera are you talking about? Line 314-316: The significant positive correlation between test size and Chl a content (Figs. 6 and 10) shows the increasing number of symbionts with host size, and a quantitative relationship in the host and symbionts based on their scaling exponent (Table 2). Line 317: "If the test shape is less spherical..." Line 318: ... (the increase in cytoplasm...) Line 321-323: "...increased in nearly proportional to the host's test volume. This kind of size scaling across different species of planktonic foraminifera suggests a robust relationship between the host and symbionts." Line 326: "...almost five times more Chl a than the microperforate non-spinose group, and 10 times more than the..." Line 329: "...spines may facilitate..." Line 330: "efficient illumination..." Lines 333-334:

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"Moreover, clear clusters correspond to each morphogroup macroperforate spinose, macroperforate non-spinose, and microperforate non-spinose. Lines 334-335: delete: "It is also an interesting feature firstly revealed in this study." Lines 339-340: "If such microenvironmental conditions surrounding the intracellular symbionts are measurable or numerically modeled, our understanding of the differences and the controlling factor of symbiont density would be improved." Line 342: "When species are grouped according to symbiont type, dinoflagellate..." Line 344: "parameters are significantly" Line 366: "...nutrients in ambient seawater..." Line 370: "...established in *G. ruber* (pink). In fact, the..." Line 379: "The present study extends our understanding..." Line 381: "Nineteen species, showed..." Lines 383-384: "Finally, we propose a new framework of photosymbiosis in planktonic foraminifera as a continuous spectrum of photosymbiosis." Lines 390-393: "Interestingly, photophysiology may be basically determined by the type of symbiont, regardless of the phylogenetic position of the host and its test morphology. Physiological parameters, in particular σPSII , seem to correspond to the overall depth habitat of the host foraminifera."

Table 1: pachyderma", rren? Fig. 1, line 574: "tropical eastern Atlantic" Fig. 2: very nice! Figures 9, 10, and 11: for didactical reasons, always give the same color for the same group Fig. 11 in the figure: "Acquired"

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