Temperature response of photosynthesis of the alpine-vegetative moss *Racomitrium lanuginosum* (Hedw.) Brid. in the Mt. Fuji

Mutsuki Iwasaki, Chihiro Azai and Fumino Maruo
Fuculty of Science and Engineering, Chuo University, Tokyo 112-8551, Japan

In a view of generally acquired plant physiology, any alpine region is not a habitable rather very stressful zone for most of plants. This is due to its low temperature, long-time snow covering, and direct solar irradiation. To overcome these environmental stresses, alpine plants are forced to shorten their time for growing and propagation to the moderate season during each year. Mt. Fuji is the well known and highest alpine in Japan. Its elevation is 3,776 m and the forest limit is between at 2,400-2,500 m (Masuzawa *et al.* 1991). The above zone from 2,500 to the top 3,776 m of elevation is thus almost bare and a hardly vegetative zone.

Racomitrium lanuginosum (Hedw.) Brid. is the bryophytes (Grimmiaceae) and the dominant vegetative species on such a bare ground above 1,000 m in the Mt. Fuji. While its observed ecological habitat is an alpine region, its adaptation to the alpine environment is still a questionable issue. For example, since male shoots of *R. lanuginosum* growing on the Mt. Fuji decrease the number of antheridia along with the elevation (Maruo 2017, Maruo *et al.* 2020), the sexual reproducibility of *R. lanuginosum* would be limited in the high elevation zone. Since development of reproductive organs depends on amount of energy surplus, which is the photosynthetic income unused for vegetative growth and housekeeping (Brazel *et al.* 2019, Raven *et al.* 2015), the photosynthetic productivity at the heigh elevation could be insufficient for completion of the antheridium development. This is also supported by the evidence that development of antheridium requires more (roughly double) resources than that of cost will be required for archegonium in plant (Charlesworth 1989).

On the other hand, we have not found any significant difference in morphology of the leaves, which are of the *R. lanuginosum* shoots sampled at 2,500, 3,000 and 3,700 m (Figure 1). This apparently suggests that the elevation does not affect the vegetative growth of *R. lanuginosum* and the photosynthetic productivity is maximized at each elevation. This is supported by the previous report for graminoid species growing another alpine region; the photosynthetic productivity adapts low-temperature stress and would be maximized in the habitat (Göbel *et al.* 2019). However, since the photosynthetic productivity is determined not only by leaf morphology but also by the organization of photosynthetic system inside the cell and chloroplast, we could not yet conclude whether *R. lanuginosum* has an adaptative phenotype in their photosynthesis or not. Therefore, we have to examine photosynthetic energy income of *R. lanuginosum* in the alpine region of Mt. Fuji.

The heigh elevation will increase many physical stresses in the alpine habitat *R. lanuginosum*, such as temperature, light intensity, humidity and so on. Here, we report response of photosynthesis against the low temperature, which is assumed to be lower in average and more severely changing at the high elevation. By the PAM fluorometry of chlorophyll, we measured photosynthetic activities of the *R. lanuginosum* leaves sampled at 2,500, 3,000 and 3,700 m, used also for the morphological analysis above. We will report and discuss the temperature dependencies from -5 and 30°C, which is averages of the growing season in the alpine regions of Mt. Fuji.

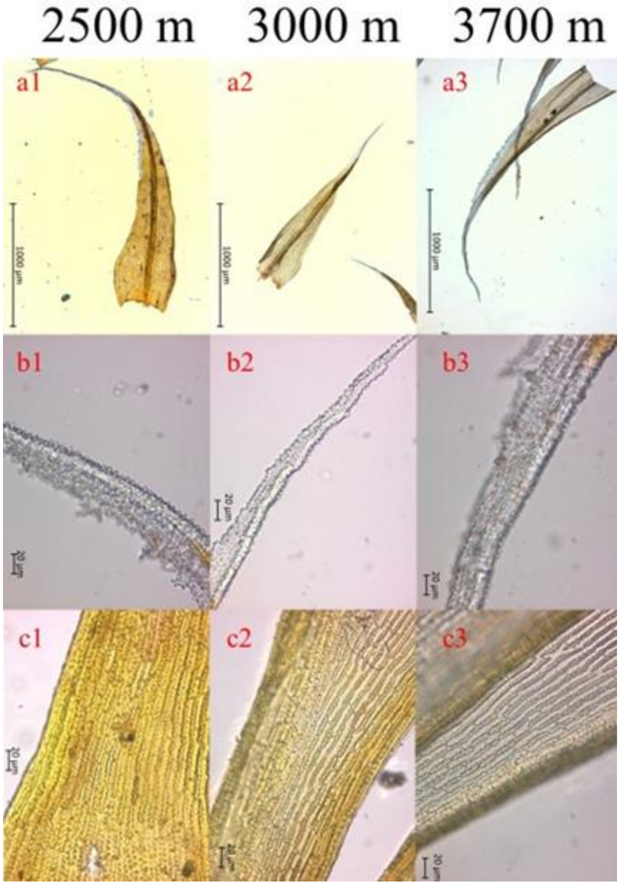

Figure 1. Morphologies of the *R. lanuginosum* leaves sampled at 2,500, 3,000 and 3,700 m of the Mt. Fuji. Each panel was a photograph taken by light-field microscopic observation. The panels with prefix of "a" are total view, those of "b" are the apex and edge part, those of "c" are the center and base part of each leaf. The number suffixes represent the elevations of samples: 1,2, and 3 are 2,500, 3,000, and 3,700 m, respectively. All the three leaves have very similar morphology. The apex and edge parts are colorless and transparent, and their shapes are narrow and lanceolate. The center and base parts are colored with chloroplasts, and the shapes of constituent cells are the long and waved rectangles due to their thick cell walls.

References

Takaki, N, The moss flora of Mt. Fuji. In: Tsuya, H. , et al. (Eds.), Fujisan (Mt. Fuji). Fuji-kyuko, Tokyo, 586-602, 1971.

Masuzawa, T. and Suzuki, J, Structure and succession of alpine perennial community (Polygonum cuspidatum) on Mt. Fuji. Proc. NIPR Symp, Polar Biol, 4, 155-160, 1991.

Maruo, F. and Imura, S, Restriction of sexual reproduction in the moss *Racomitrium lanuginosum* along an elevational gradient, Ecology and Evolution 10-18, 10066-10075, 2020.

Maruo, F, Studies on restricting parameters of sexual reproduction in the moss *Racomitrium lanuginosum*, [Dissertation, SOKENDAI(The Graduate University for Advanced Studies)], 2017.

J.A. Brazel. and D.S. Ó'Maoiléidigh, Photosynthetic activity of reproductive organs, Journal of Experimental Botany, 70(6), 1737–1754, 2019.

J.A. Raven. and H. Griffiths, Photosynthesis in reproductive structures: costs and benefits, Journal of Experimental Botany, 66(7), 1699–1705, 2015.

L. Göbel. H. Coners. D. Hertel. S. Willinghöfer and C. Leuschner, The Role of Low Soil Temperature for Photosynthesis and Stomatal Conductance of Three Graminoids From Different Elevations, Frontiers in Plant Science, 10, 2019.

B. Charlesworth, The evolution of sex and recombination, TREE, 4, 264-267, 1989.