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Winter leaf reddening phenomenon: the long-term track of PRI and phenological changes in a temperate Japanese cypress forest at Kiryu Japan.

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Winter leaf reddening is a phenomenon that evergreen species' leaf color changes into red resulting from the accumulation of red pigments before or during winter, which persists for several months before dissipating with springtime warming. Among the many hypotheses about the winter leaf reddening, photoprotection is currently the favored hypothesis. Several studies focused on leaf reddening in angiosperms species. Yet, little researches concerned about leaf reddening in gymnosperms species. In gymnosperms, a kind of xanthophyll pigment rhodoxanthin was reported to play an important role. However, the xanthophyll cycle is the main protection mechanism of plants to deal with excessive light energy.

To track the winter leaf reddening phenomenon, we utilized the carotenoid-based vegetation index, the photochemical reflectance index (PRI), which is sensitive to changes in carotenoid pigments (e. g. xanthophyll pigments) in live foliage, as a tool to reflect the invisible phenology of photosynthesis by assessing carotenoid pigment dynamics. We used the CO2 flux data and the micrometeorological data collected from the temperate Japanese cypress forest from 2014 to 2019. We also made use of the digital camera to monitor the canopy phenology changes from 2016 to 2019. The digital camera took photos in 3 hours intervals with 3 different ROI (region of interest), the RGB channels of image data were extracted to calculate the RGB chromatic coordinates and the Red-Green vegetation index (RGVI).

Our findings demonstrated that air temperature reached the lowest point had a one-month lag in the time than that of PAR. The imbalance between light energy absorption and light energy utilization might activate the photoprotection mechanism. The change in light use efficiency (LUE) might confirm this conjecture. LUE reached its peak at the end of December and then dropped sharply. It suggested the photoprotection mechanism was activated. The RGVI fluctuation showed the seasonal changes with that of PRI almost in contrast. PRI was highly correlated with RGVI

(*R=-0.806928034317071 in Pearson's correlation test*). It suggested that the winter leaf reddening phenomenon caused the decline of PRI. Further, the PRI and RGVI both were highly correlated with air temperature and PAR. Based on current observations, there are still many unclear mechanisms. In the future, we will try to better explain the mechanism of winter reddening with a new set of experiments.

Keyword: winter leaf reddening, Japanese cypress, photochemical reflectance index (PRI), Red-Green vegetation index (RGVI), phenological analysis, digital camera