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Vertical differences in autumn phenology of Fagus sylvatica L. in a mixed forest, southern Germany

Eliana Gressler (1), Susanne Jochner (2), Renée Capdevielle-Vargas (2), Patrícia Morellato (1), and Annette Menzel (2)

(1) UNESP São Paulo State University, Botany, Rio Claro, Brazil (patricia.morellato@gmail.com), (2) Technische Universität München, Fachgebiet Ökoklimatologie, Freising, Germany

Phenological variation among trees of different heights provides a small scale ecological distinction within the forest allowing the optimization of light interception and consequently net carbon gain. Several studies showed that juveniles and suppressed adult individuals can adopt a “phenological escape" strategy by leafing out earlier during spring or by delaying autumn phenology in relation to adult overstory trees. While spring phenological variations in temperate forests were well studied, for autumn phenology it is still unclear whether ontogenetic or microclimatic factors are more decisive.

We regularly observed leaf coloring and leaf fall phenology of 166 European beech individuals (Fagus sylvatica L.; Fagaceae), during autumn 2012 in a mixed forest (Kranzberger Forst) in southern Germany and installed 18 loggers for measuring air temperature and humidity at different sites and heights. Our objectives were: (1) to identify microclimatic differences at our observation sites (2) to determine the extent of phenological variations between trees of different life stages (overstory, mesostory and understory); and (3) to examine whether phenology varies between three different height canopy levels.

We found that temperature data did not differ between height levels, but relative humidity was significantly higher in the lowest parts. In addition, overstory individuals were the first to start autumn phases followed by mesostory and understory trees. Leaf colouring and fall for understory trees appeared 31 and 23 days later compared to overstory trees. The transition of autumn phases (from the beginning of leaf colouring until the end of leaf fall) was most and significantly extended for overstory trees (mean of 62 days), followed by mesostory (46 days) and understory (38 days). Understory individuals started leaf colouring even 4 days after the onset of overstory leaf fall evidencing phenological avoidance between life stages. Besides this analysis of life stages we also found that upper canopy parts of individual trees were characterized by the earliest appearance of autumn phases; mean difference in onset of leaf colouring and fall between upper and lower levels was in each case -11 days. Mean peak dates did not differ between the highest canopy levels. Thus, transition of autumn phases was fastest for the lowest canopy level (mean of 19 days) than for the highest levels (35 days).

Our results suggest that the observed differences were probably not related to temperature but to microclimatic variations in relative humidity and light availability. Furthermore, autumn phases of lower individuals (mesostory and understory) and lower canopy height parts were associated with a shortened transition of autumn phenological phases, probably also associated with fewer branches and leaves that might facilitate the synchronization of phenology. Since phenological development can considerably differ, generalizations are limited when considering trees of different life stages within a forest. Further studies should focus on autumn light conditions to investigate its influence on phenology and the possible gain of light acquisition during phenological avoidance.