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学 位 論 文 内 容 の 要 旨

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学 位 論 文 題 名

Dynamics of different branching units in crowns of Sakhalin spruce, *Picea glehnii* (F. Schmidt) Mast.
（アカエゾマツ*Picea glehnii* (F. Schmidt) Mast.の樹冠における異なる分枝ユニットの動態）

Growth and death of branches largely determine the development of crown architecture, which in turn strongly affects not only growth and survival of trees, but also the structure, dynamics, and productivity of forest stands. Therefore, it is crucial to identify the factors controlling branch growth and death within tree crowns to construct reliable models for predicting the growth and development of trees as well as for providing useful guidance for forest management. Because of mutual-shading from neighboring individuals or self-shading within a tree crown, light intensity is commonly heterogeneous within a tree crown in a natural stand. Although light is known as an important factor affecting crown formation and development of various tree species, the role of light in the growth and survival of branches, especially at different levels of branching units, within a tree crown is still poorly understood.

In this study, I investigated the effects of light intensity and other morphological factors on the growth and death of branches and the growth of epicormic shoots in trees of a plantation of *Picea glehnii* (F. Schmidt) Mast. (Sakhalin spruce) in the Sapporo Experimental Forest of Hokkaido University, Sapporo, Hokkaido, Japan. In this study the branches forking from the main trunk were defined as primary branches, and those branching from a primary branch as secondary branches. An epicormic shoot is a shoot initiated from a bud that had been dormant underneath the bark of a branch. Local light intensity was represented by relative photosynthetic photon flux density (rPPFD) recorded above a branch. Trees were categorized into sunlit trees and shaded trees according to their rPPFD above the treetop.

Results showed that, as expected, local light intensity had a significantly positive effect on the number of current-year shoots (shoot number) and length of current-year shoots (shoot length) of both primary and secondary branches in the entire crown. However, the effects of rPPFD exhibited several differences between primary branches and secondary branches, and between sunlit trees and shaded trees. For the primary branches in the upper half of the crown of sunlit trees, the shoot length was shorter than that on shaded trees under a relatively low rPPFD range, but the shoot length of the sunlit trees exceeded that of the shaded trees as rPPFD increased. Meanwhile, at the distal part of a primary branch, secondary branches on shaded trees produced

significantly more current-year shoots than those on sunlit trees when branches under similar light levels were compared. However, shoot number increased more sharply on sunlit trees than on shaded trees as rPPFD increased.

Furthermore, local light intensity also had a significant effect on the probability of death of both primary and secondary branches. However, the relative influences of its effect on the growth and death of branches were different between these two branching units. In primary branches, shoot number and shoot length were mainly affected by local light intensity, whereas the probability of death of a primary branch was equally affected by both local light condition and the primary branch position within a crown (i.e., the length between basal location of a primary branch and the crown base). A similar result was obtained by another field measurement in which primary branches in a lower part of the crown under a low range of rPPFD (< 3%) were investigated; in this range of rPPFD, the probability of producing one or more current-year shoots on a primary branch was significantly affected by local light intensity. However, the probability of death of primary branch was significantly affected by branch position, while the effect of local light intensity on branch death was not significant.

In contrast to primary branches, the relative influence of local light intensity on shoot production, shoot length and the death of secondary branches all exceeded 65%, indicating that both the growth and survival of a secondary branch mainly depended on its own photosynthetic capability.

In addition, local light intensity had no significant effect on the number of current-year epicormic shoots on primary branches. Primary branches on shaded trees produced more current-year epicormic shoots than those on sunlit trees. Therefore, the production of epicormic shoots occurs in Sakhalin spruce as a normal and an integral part of crown architectural development, and is likely to be a component of a strategy that prolongs tree longevity, especially for those less vigorous Sakhalin spruce trees.

In conclusion, this study revealed that (i) local light intensity alone cannot fully explain the growth and survival of branches, (ii) growth of branches may be inhibited when other branches are under a stronger light intensity within the same crown, (iii) the role of light in the growth and survival varies between different levels of branching units, and (iv) growth of epicormic shoots is likely to be an adaptive growth strategy in the development of crown architecture to maintain crown productivity of Sakhalin spruce.