NOTES

Adventitious Roots of *Eucalyptus robusta* in Hawaii

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ADVENTITIOUS ROOTING on the trunks and limbs of *Eucalyptus robusta* Sm., a species widely planted in Hawaii, is a remarkable example of how a new environment can change a plant's growth habit. *E. robusta* is native to swampy areas on the coast of southeastern Australia, where annual rainfall ranges from 40 to 60 inches (Forestry and Timber Bureau, 1957). Layering of prostrate stems sometimes occurs there, but adventitious roots on standing trees seem to be unknown.[2]

ORIGIN AND GROWTH OF THE ROOTS

Newly initiated roots may grow through the thick fibrous bark into the open air, or they may grow downward while remaining within the bark. LeBarron (1962:18) reported that these roots can extend to the ground separate from the trunk. In all cases I have observed, roots that grew into the open died back when only a few inches long. I tried to trace several of these roots by dissecting trunk sections at the point where a root appears, but in all cases the root traces disappeared at a point outside of the trunk pith.

Typically, the young roots remain inside the bark, branching freely. Eventually they enter the soil at the base of the tree without having had their growing points exposed to the air, except for brief periods when they grew out of a ridge of bark, across a fissure, and into an adjacent ridge.

Growing roots thicken and eventually burst through the bark. This process, aided by gradual sloughing of the outer bark, places the adventitious roots outside the trunk (Fig. 1), but by then the roots are protected from dessication by their own bark. In extreme cases, large roots may completely conceal the trunk.

OCCURRENCE OF ADVENTITIOUS ROOTS

Stands in which trees commonly bear adventitious roots are generally in wet climates. Thus, these roots are common in Hilo, Piihonua, and Mountain View, where median annual rainfall is 147, 210, and 195 inches, respectively (Taliaferro, 1959), and comparatively uncommon at Waikii, Honokaa, and Laupahoehoe (m. a. r. 23, 88, and 100 inches, respectively). At Waimea and Puu Kapu (m. a. r. 39 and 48 inches) frequent fogs compensate for low rainfall and permit adventitious roots to persist.

Within a closed stand, large adventitious roots are found mainly on "wolf" trees and border trees. Open-grown trees with massive spreading limbs generally have the largest adventitious roots (Fig. 1). In contrast, small-

FIG. 1. Strongly developed adventitious roots emerging from crotches of open-grown *E. robusta* near Kurtistown, Hawaii.

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FIG. 2. Trunks of small-crowned trees in closed stands, normally free of persistent adventitious roots. This stand is in Glenwood, Hawaii.

crowned, fine-limbed trees typical of dense forests usually have trunks free of all but the finest roots (Fig. 2).

Persistent adventitious roots generally emerge from the upper trunk, crotches of large limbs, and the underside of large limbs. No large roots have been found emerging from the upper surface of a limb, or from a point low on the unbranched portion of a trunk.

DISCUSSION

Adventitious rooting is controlled by moisture level of the bark. *E. robusta* bark is fibrous, absorbent, and more than 7 inches thick on some large trees. It is an efficient reservoir for water. In some areas it is almost continuously saturated. Both rainfall and fog drip are effective in maintaining high bark moisture content.

Some parts of a tree receive more water, in the form of stemflow, than others. Stemflow is concentrated in large crotches and on the main stem. Because *E. robusta* bark is absorbent, water drains to the lower surface of a near-horizontal limb as well as down the limb toward its junction with the trunk. The bark on the lower side of the limb may be a more effective reservoir, being about twice as thick as the upper-side bark (e.g., 1/2 vs. 1/4 inch) and less subject to drying during periods of clear weather. Penfound and Mackaness (1940:168) also found distinct "flowways" running down the spreading limbs of live oaks and down the trunks. Most of the live oak stemflow coursed along the upper surface of the limbs, probably because the bark was not highly absorbent.

By examining trees after showers, an observer can discriminate wet and dry zones of the bark by their appearance or by feel. He can see that trees with high small crowns often conduct only enough stemflow to saturate the limbs. But spreading-crowned trees with massive branch systems channel enough stemflow down the trunk to saturate the bark for a considerable distance below the crown. Thus, the location of wet bark is partly governed by crown size and configuration. Inasmuch as these attributes are strongly influenced by spacing, adventitious roots are unlikely to become prominent on trees in closed stands.

A somewhat analogous situation is the layering of woody plants into pads of moist humus accumulated by epiphytes (Herbert, 1958:23). But in *E. robusta* the bark itself is the medium that supplies moisture to the adventitious roots.

E. robusta has been planted in other tropical countries (Penfold and Willis, 1961), and adventitious rooting will probably be encountered wherever moisture conditions are satisfactory. M. R. Jacobs, in a letter to the author in 1963, said that he observed such rooting in Uganda and Argentina. There is also a recent report of adventitious roots of *E. robusta* and *E. camaldulensis* Dehnh. in a greenhouse in Russia, where relative humidity was maintained at 80–90% (Gerasimov, 1962:1531). In Australia, *E. camaldulensis* puts forth adventitious roots

from parts of the lower trunk subject to periodic flooding (Jacobs, 1955:145). But because *E. robusta* does not grow under conditions favorable to root induction, its ability to form such roots is not evident within its natural range.

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