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How do climbing palms climb and why are they so long?

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Climbing plants require a combination of mechanical properties during their growth that differs radically from self-supporting trees and shrubs. This mechanical requirement appears to be the same across many major groups of plants including monocots and dicots. One of the main trends in mechanical properties during development in climbers is the shift from relatively stiff to highly flexible stem properties. Whereas most woody dicotyledons produce this kind of change via elaborate secondary growth, climbing palms must produce stiffness, then flexibility by other means. The appearance of a very similar climbing habit in both the *Arecoideae* and *Calamoideae* has fascinated botanists for many years, especially since true rattans have some of the longest plant stems known. We investigated the developmental and biomechanical traits that are linked to attachment and stem biomechanics in both groups. The developmental constraints existing in palms including the lack of secondary growth have a profound influence on the kind of mechanical strategy adopted by climbing palms. The shift from high stiffness to high flexibility is made possible by the development of a stiff outer leaf sheath in early growth and then its senescence and loss during later development. Furthermore, when axes possessing a leaf sheath are submitted to overwhelming bending forces - such as during tree-falls - shattering of the leaf sheath releases the critical strains and fracture surfaces are not propagated across the internal stem. A major developmental constraint in palms linked to the continuous production of leaves at the stem apex, has a particularly profound effect on the climbing life histories. Whereas senescence of the leaf sheath provides a “cheap” way of producing high flexibility – compared with woody lianas, that same senescence also removes the mode of attachment on which the plant relies on to maintain its position and survival. Rattans are famous for their extremely long stems that can be several times longer than the height of the forest canopy in which they grow. More specifically, the extreme lengths of rattans and some arecoid climbers such as *Desmoncus*, result from a positive feed-back loop between attachment and the necessary stem mechanics. First, slender stems of canopy climbers must become flexible or they will be liable to fail. Second, to remain attached in the forest canopy, climbing palms must continue to produce more cirri or flagella and more stiff lengths of young stem/leaf sheath to access new supports as the established attachments fail. The positive feed-back between traits in climbing palms can be likened to a Red Queen dynamic whereby climbing palms must keep growing to stay in the same place.

Keywords:
Biomechanics, climbing palms, trait integration, Red Queen dynamic