生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	葉片防止結凍 (Leaves Protect From Freezing)
生物系統 LIVING SYSTEM	矮千里木 *Dendrosenecio keniensis* (Giant groundsel)
功能類別 FUNCTIONS	#保護免受溫度危害 #Protect From Temperature
作用機制標題	矮千里木隔熱的外層葉片透過在晚上時向內捲起，包裹幼嫩的內層葉片，保護其免於凍結 (Insulated outer leaves of the cabbage groundsel protect tender inner leaves from freezing by folding inward to enclose them at night)
生物系統/作用機制示意圖	

作用機制摘要說明 (SUMMARY OF FUNCTIONING MECHANISMS)

介紹

矮千里木 (*Dendrosenecio keniensis*) 是一種葉片簇生的灌木植物，生長在東非肯亞山 (Mt. Kenya) 海拔約 3000−4000 公尺（10000 至 13000 英尺）的山坡上。它盤子大小的厚葉子形成蓮座狀葉叢 (rosette)，由 50 片或更多片較老、較堅硬的葉子，環繞著在中央形成嫩芽狀的一叢嫩葉。

策略

矮千里木生長在岩石多又貧瘠的環境，那裡在白天溫暖且陽光充足，然而到了晚上，溫度經常下降到零度以下。寒冷可能會阻礙蓮座狀葉叢中新生葉子的生長，除非有一樣東西：圍繞在新葉外圍老葉片的隔熱能力。質地厚實、皮革狀的外層葉子內部有氣袋，能夠減緩熱量的傳播，就像保麗龍冷藏箱的原理一樣。

當溫度隨著黃昏降臨而驟降時，大葉片中的一些細胞將液體釋放到細胞之間的空間，從而內表面 (inward-facing surface) 變得不那麼僵硬。因此，葉子向上和向內合攏，在植物較幼嫩部分周圍形成一層隔絕層，保護新生的葉叢免受寒害。雖然外層葉片會凍結，但它們足夠耐寒 (hardy) ，能在隔天於幾分鐘之內重新打開來獲取早晨陽光時解凍。

潛力

我們對於帶有氣囊之厚層材料的隔熱能力已經相當熟悉。例如隔熱的泡沫牆和羽絨被。把矮千里木的特性與移動性隔離層 (moving insulation) 的溫度觸發機制結合，可能對於保護景觀植物 (landscape plant) 免受霜凍或提高整棟建築的能源效率會很有用。

Introduction

The cabbage groundsel (*Dendrosenecio keniensis*) is a shrub-like plant with clustered leaves found at elevations of around 3000–4000 meters (10000 to 13000 feet) on the slopes of Mt. Kenya in eastern Africa. Its thick, platter-sized leaves form a rosette, with 50 or more older, tougher leaves encircling a cluster of tender young leaves that form a bud shape at the center.

The Strategy

The rocky, barren places the cabbage groundsel grows are warm and sunny during the day. At night, however, temperatures regularly drop below freezing. The cold could stunt the growth of the newly emerging leaves in the center of the rosettes except for one thing: The insulating power of the older leaves that surround them. The thick, leathery outer leaves have air pockets inside them that slow the movement of heat, much as a styrofoam cooler does.

When temperatures plummet as dusk falls, some of the cells in the large leaves release fluid into the space between cells, causing the inward-facing surface to become less stiff. As a result, the leaves fold upward and inward, forming an insulating layer around the more tender parts of the plant and protecting the newer, clustered leaves from the cold. The outer leaves freeze, but they are hardy enough to thaw out the next day, when they reopen within minutes to catch the morning sun.

The Potential

We're already quite familiar with the ability of thick layers of material with air pockets to insulate. Consider foam wall insulation and down comforters, for instance. Combining that trait, as the cabbage groundsel does, with a temperature-triggered mechanism for moving insulation could be valuable for everything from protecting landscape plants from frost to improving the energy efficiency of entire buildings.

文獻引用 (REFERENCES)

「巨型蓮座狀植物的典型特徵是成熟葉片能夠進行特殊運動 (movement) 的能力。葉片在寒冷時向上勇及向內彎曲，而且由於蓮座狀植物由大約 70−200 片成熟葉所組成，這樣的運動導致整個系統呈現圓球形，被稱為「夜芽(night-bud)」…葉片的反向運動在回暖時發生，蓮座狀葉片會打開到白天時的位置。夜芽的密集層次有效地隔離了內部葉片，尤其是分生組織核心上葉片，使其免受夜間霜害。」(Beck 1985: 83)

「在夜間霜凍期開始時，非洲高山地區 (afroalpine) 巨型蓮座叢植物的成熟葉片會感夜地 (nyctinastically) 向上和向內彎曲，使整個蓮座葉叢呈圓球形。這又稱為夜芽…在夜晚或多或少為芽體周圍提供了密封和隔離的氣室 (air space)，但是當早晨的第一縷陽光照射而變溫暖時，它會迅速打開。由於 Beck 等人顯示發育中葉片與成熟葉擁有幾乎一樣的抗霜凍能力，以夜芽方式保護葉芽免受冰點以下溫度的影響，可以說是一種防止葉子在夜間因凍結而停頓生長的手段，而不是避免冷凍傷害 (cryoinjury)。」(Beck 1982: 128)

"A typical feature of the giant rosette plants is the ability of the adult leaves to carry out special movements. The leaves bend upwards and inwards upon cooling and since the rosettes are composed of some 70–200 adult leaves, this movement results in the whole system taking on a globular shape which has been designated a 'night-bud.' … The reverse leaf movement takes place upon warming, thus opening the rosette to its day position. The dense layering of the

night-bud effectively insulates the inner leaves and especially the core of meristematic leaves from nocturnal frosts." (Beck 1985: 83)

"Upon onset of the nocturnal frost period, the adult leaves of the afroalpine giant rosette plants nyctinastically bend upwards and inwards, giving the whole rosette a globular shape. This so-called night-bud … provides a more or less sealed and insulated air space around the bud-cone during the night, but rapidly opens upon warming by the first rays of sunshine in the morning. Since Beck & al. … have shown that the developing leaves are almost as frost resistant as the adult ones, protection of the leaf-bud from subfreezing temperatures in the night-bud may be interpreted rather as a means to prevent nocturnal stand-still of leaf growth due to freezing than to avoid cryoinjury." (Beck 1982: 128)

參考文獻清單與連結 (REFERENCE LIST) **Harvard 或 APA 格式**

Beck, E. (1985). Tropical alpine environments. Plant form and function. *Cambridge University Press*. England.

Beck, E. (1982). Biology of afroalpine *Dendrosenecio* (Asteraceae). *Plant Systematics and Evolution*. 152: 123-131. (https://link.springer.com/article/10.1007/BF00985353)

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