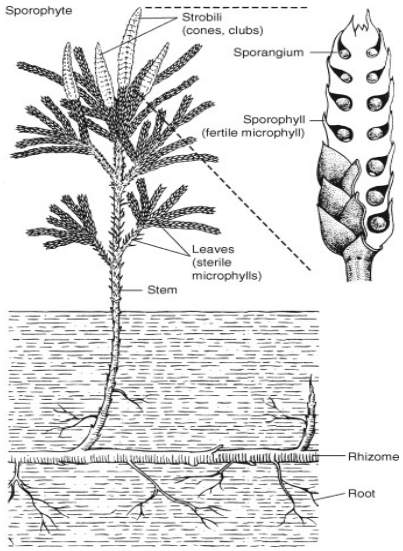
Ancient Tiri Part 11: Adventures in "Deep Time". The Clubmosses – the first Tracheophytes (Vascular plants).

Clubmosses are present on Tiri in a just few isolated locations. They are easily overlooked as they are small, flowerless and inconspicuous, often found hiding in the shadow of other taller plants and trees.
So why should we grant them an issue of *Ancient Tiri* all of their own? What could be so important about them? In short, they represent an evolutionary link between the primitive Bryophytes (Mosses and Liverworts) and the modern Tracheophytes (*vascular* plants with *internal tubes* that *carry water* up their tall stems).

Lycopodium cernum on the Wattle track. *J.S.*



Clubmoss anatomy Wikimedia Commons

Mosses have no water vessels, *soaking* water up the *outside*. JS.

In Part 4 of *Ancient Tiri* we looked at the mosses and how they do not possess true leaves or vascular stems, relying on the "*wick effect*" to soak water up the *outsides* of their bodies. Consequently they can only live in the wettest and most humid of environments. Mosses grow in dense carpets or rounded "blob" shaped colonies and rarely grow taller than a few cm to *reduce their surface area* in order to *minimise desiccation*. Clubmosses on the other hand are vascular – they have *tubular xylem vessels* running up their stems delivering water to each tiny *microphyll "leaf".* This means they can live in much *drier places* than mosses, and *grow much taller*. The importance of these vascular precursors as an evolutionary stepping stone towards the more advanced plant life we see around us today cannot be overstated.

Part of a moss leaf with a simple single-cell layer "leaf" structure, plus a strengthening "midrib" with *no water carrying function. J.S.*

A complex multi-cell layer *clubmoss* "leaf" with a *water carrying vein,* showing stomata to control water loss *as in higher plants. J. S.*

These vascular clubmosses represent a giant leap in the evolution of plants allowing them to *completely colonise* the land. Moss "leaves" are primitive structures *one or two cells thick*, but clubmosses have *thicker robust leaves*, each with a *tiny vein* supplying water, a *multi layered internal structure* and even the *first appearance of tiny mouth-like stomata* to allow for *gas exchange* exactly like modern plants.

Clubmosses or lycophytes are so named because of their *moss like appearance* and their *club shaped "cones"* borne at the tips of fertile stems. They are flowerless and seedless plants in the family *Lycopodiaceae* and they belong to an ancient group of plants of the division *Lycophyta*. They have dichotomously branching (split in two) stems bearing simple leaves called *microphylls* and like the mosses *reproduce by means of spores* borne in *sporangia* on the sides of the stems at the bases of the leaves. Phylogenetic studies (the study of classification) place them at the base of the *evolution of the first vascular plants* and they have a long evolutionary history.

An artists impression of a giant clubmoss forest in a Carboniferous swamp. Wikimedia

Fossil clubmosses are abundant in rocks worldwide, especially in *coal deposits*. Fossil "proto-club mosses" first appeared in the Silurian period (443-419 Ma), along with a number of other vascular plants.
They are still a *worldwide plant family* and although they occur from tropical regions to the Arctic they are now a *small and inconspicuous* group compared to their heyday 400-300 Ma during the Carboniferous period when clubmosses dominated the major habitats of the Earth and were *forest-forming trees* taller than 35 metres making them the *oldest group* of vascular plants living today.

The Clubmoss life cycle with the subterranean gametophyte top right. Wikimedia commons

There are differences in leaf structure between the club mosses and other vascular plants. It appears that the clubmoss microphyll has *evolved independently* from those of other vascular plants. Microphylls have only *one unbranched strand* of vascular tissue (vein) whereas the megaphylls of other leafy plants have *multiple veins*, usually *branching* one or more times within the leaf.
The familiar clubmoss plant we see is the *dominant sporophyte* generation producing spores, which then germinate into *small independent gametophyte* plants which live under ground for up to two years. (Remember mosses – they have a sporophyte (spore capsule) growing parasitically on top the dominant gametophyte plant).

A modern *Mahoe* megaphyll showing multiple branching veins. *J.S.*

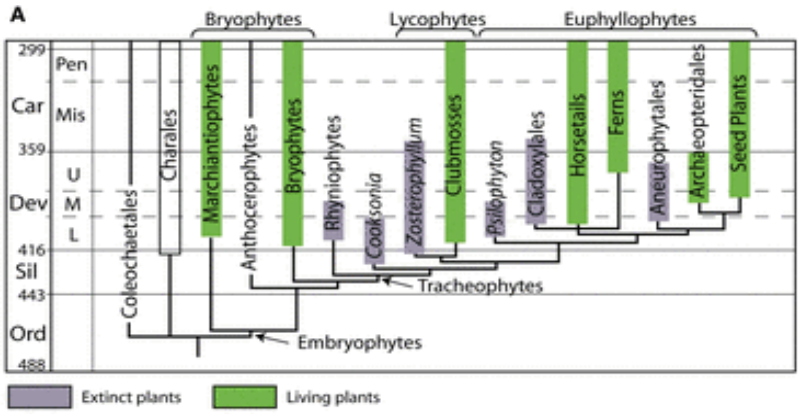
Lycopodium cernum growing next to the East Coast Track at the top of Lighthouse Valley. *J.S.*

These underground gametophytes produce *sperms and eggs* which after *fertilisation* develop into the familiar *sporophyte plants* we see *above ground* as clubmosses.
The *subterranean gametophyte* generation has a bizarre survival strategy in the *dark*, forming a *partnership* or *association* with a *glomalean fungus* which essentially *feeds it* during the 2 years of its underground life. This partnership is called an "*arbuscular mycorrhizal association*". What the fungus gets out of this partnership is largely unknown. In some clubmoss species fungal associations are known to *transfer food* from the nearby photosynthetic sporophyte to the non-photosynthetic underground gametophyte to *keep it alive*. The above-ground photosynthetic sporophyte plant *also* has a root based arbuscular mycorrhizal association helping it to absorb soil nutrients.

Where can these ancient plants be found today on Tiri? Look out for a single small clubmoss plant called *Lycopodium cernum* (the stags horn or nodding club moss) growing on the Wattle Track in the Nikau Grove (see photo on first page). It looks rather like a small Christmas tree at the moment! It has not developed the characteristic nodding "cones" yet and may turn brown as the summer heat sets in.

Spore bearing cones on L. cernum. *J.S*

As you walk towards the lighthouse it is next to the smallest of the three nikau palms on the left of the track. I have marked it with a pink tape as it is near a research track and vulnerable to trampling. The other examples on Tiri are around a marshy area in the valley above Pohutukawa Cove where a stream meets the East Coast Track, and also above Lighthouse Valley on the East Coast Track.



This diagram helps to show where the club mosses (Lycophytes) fit in between the bryophytes and the higher plants.

Before the Tracheophytes evolved, the only plants colonising the dry land were the *Bryophytes* (Mosses and Liverworts) huddled in damp gulleys or around the moist margins of pools and streams. A few metres beyond this damp fringe the dry rock would have been mostly barren, perhaps peppered with lichens living for the rains and lying dormant in suspended animation during dry periods.

As the Tracheophytes completed their colonisation of these remaining drier areas of land, the animals soon followed, feeding on them and hiding in the decayed leaf mould and soil the plants produced.
These early invertebrates would have been the first *"pioneer"* insects, myriapods and arachnids to colonise the land, forming the *first terrestrial food chains*.

These humble little animals still inhabit the damp leaf litter on Tiri today, unchanged since Silurian times. If you see a saddleback or robin feeding in the leaf litter they are probably seeking these tiny living fossils.

Collembola (springtails). Ancient wingless insects J.S.

Poduromorph springtail. J.S.

A predatory false scorpion. J.S.

So in a very real sense, when you guide a group of visitors along our amazing Tiri tracks, you are taking a walk back in deep time – hundreds of millions of years back to a time when these plants and animals had the Earth to themselves – a time when clubmosses were the giants of the forest and the biggest animals around needed a magnifying glass to see them!

In the next issue of "Ancient Tiri" we shall look at the evolution of the Ferns and some of the invertebrates that lived alongside them.

John Sibley 2019