Tracking genes in paper mulberry

Paper mulberry are plants with many uses – medicine, paper, tapa. By analysing its DNA scientists can tell us about the relationships between different populations. This analysis has also helped scientists unravel the journey of the first people to colonise the Pacific. Mike Stone explores the science.

Tapa's cultural significance

Bark cloth is important across the Pacific, known by different names – siapo (in Samoa), kapa (Hawaii), masi (Fiji), ngatu (Tonga); tapa is a generic name for all of these. Each culture has its own distinctive designs, textures and production methods.

Tapa are made to be used, displayed and gifted and are an important part of birth, marriage and death ceremonies. However as Pacific people converted to Christianity and began to use European cloth, the plant declined and has died out in some places.

Tapa production

This cloth is made from pounded inner tree bark. Raw material is taken from young trees, dried, soaked, and then beaten with a wooden mallet. The flattened bark is spread into very thin sheets and dried in the sun. These sheets are combined to make a tapa cloth.

Tapa is most commonly made from paper mulberry, *Broussonetia papyrifera*, although it was also made from fig and breadfruit. Paper mulberry is grown as an annual crop, propagated from root suckers or stem cuttings and harvested as spindly poles around 2 m tall.

Genetic analysis

Bárbara Peña-Ahumada, a scientist from Chile, led a team to genetically analyse tapa made from paper mulberry using ancient and contemporary samples.

Due to its great cultural significance, tapa is kept and handed down for generations – and some is held in museum collections. The scientists found 16 tapa samples from Rapa Nui, Hawaii, New Guinea, Fiji, Samoa and Gambier Is. They cut a small sample of each tapa, extracted its DNA and used PCR to make many copies.

Skinny stems of paper mulberry grown for tapa on Tongatapu, 1987. Auckland War Memorial Museum/Tāmaki Paenga Hira.

A region of ribosomal DNA (rDNA) and a set of 10 nuclear microsatellites were sequenced so they could be used as genetic markers to analyse the samples.

The rDNA was used to identify the plant species (normally this is done from chloroplast DNA but paper mulberry bark is white so has nom chloroplasts).

As this species has separate male and female plants a sex marker was also used. The genetic markers identified alleles (different genetic sequences for the same genetic marker),

Preparing tapa, Hawaii, 2006, Maui Nui Botanical Garden. Forest & Kim Starr, CCBY3.0.

Origin of alleles detected in an ancient tapa from the Gambier Islands. Pena-Ahumada, 2020.

often more than one for each marker. This is because plants are polyploids (unlike humans who have two copies of each chromosome, plants have multiple copies).

Some of this DNA, even from modern tapa, was highly degraded (damaged and broken into small fragments). This can be due to the harsh treatment of the bark fibre (beating, washing with salt water), the hot and humid environments of the Pacific, and oxidative damage.

This 2019 star map by Nikau Hindin is a tool to help learn the declinations of the stars. From the cover of Crafting Aotearoa: A cultural history of making in New Zealand and the wider Moana Oceania, *edited by Karl Chitham, Kolokesa Māhina-Tuai and Damian Skinner.*

So sometimes there was not enough quality DNA to analyse. This meant the markers used had to be short (100-250 base pairs) to work on small DNA fragments.

They found:

- Nine of the tapa were made from paper mulberry, sometimes a mix of different varieties of the one species.
- A genetic diversity in paper mulberry – 32 new alleles and 64 different genotypes.
- Older tapa had 22 more alleles than new tapa, suggesting alleles have been lost over the last 100 years.
- It was not possible to identify the island of origin for tapa if this was unknown.

By comparing the same genetic markers in modern species of paper mulberry, the scientists could trace the tree's origins from mainland Asia (where it was used to make paper) to Taiwan and across the Pacific.

This plant was spread by humans, and by analysing other such plants and animals, scientists have been able to trace the journey of ancient humans across the Pacific and to NZ.

Such 'canoe plants' were carried with the first colonists who settled the Pacific Islands. It was also important to peoples who arrived in the Pacific from China in more recent history.

Paper mulberry in Aotearoa

Aute/paper mulberry was introduced into Aotearoa by the ancestors of Māori. Although prized in Polynesia, it was difficult to cultivate in our cooler climate, and never thrived. These plants seem to have died out in the 1840s, although there have since been re-introductions.

The only evidence for the manufacture of aute in Aotearoa are 15 pāoi/aute beaters found in North Island swamps and coastal mud, all made from native timbers.

Paper mulberry never grew very abundantly here, so it was rare and only made for special, high status objects, rather than tapa to wear.

Instead it was beaten thinner, and rolled into small pieces to make earrings worn by high status men. It was also one of the materials used to construct manu aute/kites.

Only female paper mulberry plants exist in the Pacific so it took human intervention to reproduce – it did not propagate naturally.

References

Peña-Ahumada, B, et al, 2020, A tale of textiles: Genetic characterization of historical paper mulberry bark-cloth from Oceania. *PLoS ONE 15*(5): e0233113. https://doi.org/10.1371/journal.pone.0233113

TSY Lam Museum of Anthropology (a reading, video and activity) https://lammuseum.wfu.edu/2023/05/pacific-islands-paint-a-tapa-cloth/

Auckland Museum, Paper mulberry: Prized across the Pacific, https://www.aucklandmuseum.com/discover/collections/topics/paper-mulberry-prized-across-the-pacific

2019, Nikau Gabrielle Hindin, Crafting Aotearoa: The ancestry of Te Aute *E-Tangata*, https://e-tangata.co.nz/reflections/crafting-aotearoa-the-ancestry-of-te-aute/

Useful reading

2020, August. The art of aute, *School Journal* Level 3, https://instructionalseries.tki.org.nz/Instructional-Series/School-Journal/School-Journal-Level-3-August-2020/The-Art-of-Aute.

2019, The Long Pause: *Connected,* Level 3, https://instructionalseries.tki.org.nz/Instructional-Series/Connected/Connected-2019-Level-3-Shifting-Views/The-Long-Pause.

Questions

1 In what ways does the one species of paper mulberry vary genetically?

2A What gene tracking method was used here?

2B Why was it used?

3 What did the genetic analysis tell us?

Samoan handpainted tapa. Timothy S. Y. Lam Museum of Anthropology, USA.

Stripping the bark off paper mulberry before beating. Omoa billage, island of Fatu Iva, Marquesas islands, French Polynesia. Sémhur.

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