

Bayesian phylogenies as a tool to explore linguistic and cultural diversity: the case of Kra-Dai languages and the evolution of loom technology

Guillaume Jacques

CNRS-EPHE-CRLAO-INALCO

Thomas Pellard, Robin Ryder, Emma Kopp, Chris Buckley

October 17, 2025

Linguistic and cultural diversity

1. Linguistic documentation, material culture and archaeolinguistics

Linguistic and cultural diversity

1. Linguistic documentation, material culture and archaeolinguistics
2. Bayesian phylogenies in linguistics

Linguistic and cultural diversity

1. Linguistic documentation, material culture and archaeolinguistics
2. Bayesian phylogenies in linguistics
3. Comparing linguistic and loom phylogenies

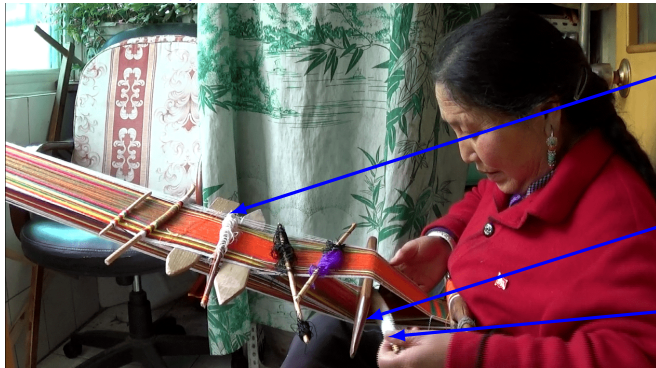
Linguistic documentation and material culture

Jacques et al. (2025)



Linguistic documentation and material culture

Jacques et al. (2025)

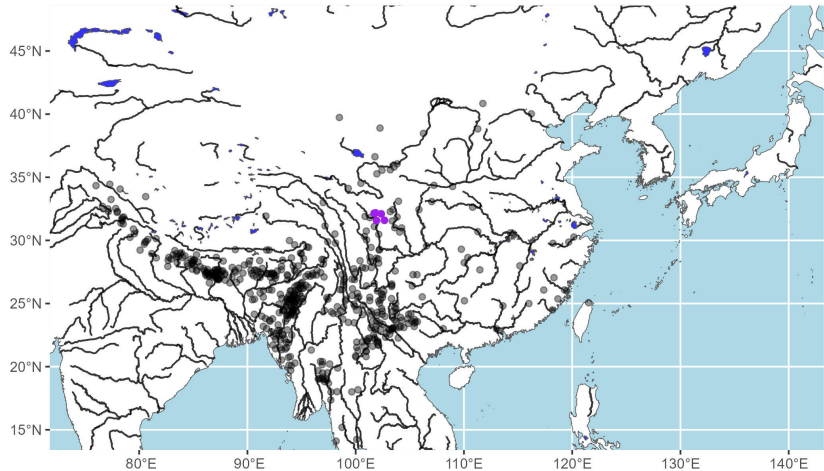


ɕnat 'Heddle'

tʰakmu 'weft beater'

tu-jlɣβ 'weft'

Rgyalrong languages



Comparative vocabulary

	Tshobdun	Japhug	Situ
Backstrap	<i>rketábʔ</i>	<i>tuutab mt^huixtɕʁ</i>	<i>tə-ɕt^hák</i>
Cloth beam	<i>tɕ^hozâr</i>	<i>tɕ^huizui</i>	<i>ta-rtɕ^híʔ</i>
Upper part of cloth beam		<i>ui-rkʁn</i>	
Lower part of cloth beam	<i>o-rⁿgǰɔɁ</i>	<i>ui-rq^hioɁ</i>	
Weft beater	<i>t^hábmo</i>	<i>t^haɁmu</i>	<i>k^harmóʔ</i>
Shed rod	<i>t^haɁɕê</i>	<i>t^haɕɕa</i>	<i>k^hatsâ</i>
Heddle	<i>ɕnê</i>	<i>ɕnat</i>	<i>mdʒenêz</i>
Heddle stick		<i>ɕnanndzu</i>	<i>mdʒenɛdʒóʔ</i>
Weft	<i>ylévʔ</i>	<i>ui-ɟlɣβ</i>	<i>tə-kláp</i>
Weft stick		<i>ɟlɣβndzu</i>	<i>tə-kləpdʒóʔ</i>
Warp		<i>ui-ɰjar</i>	<i>tə-rjêp</i>
Warp crossing	<i>o-sqérʔ</i>	<i>ui-sqar</i>	
Coil rod	<i>zgrâl</i>	<i>zgruul</i>	<i>ta-lonlíʔ</i>
Warp beam	<i>ɕnéɭɁ</i>	<i>tɣyle</i>	<i>ɕnekérʔ</i>
Warping frame	<i>sérⁿdzi</i>	<i>sɣrndzo</i>	<i>sardzô</i>

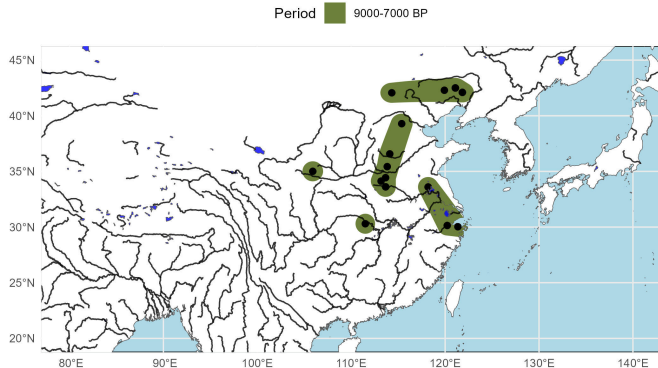
Archaeolinguistics

- ▶ Japhug *pyo* 'to spin'
- ▶ Tibetan རསང་མ་ **p^hañ.ma* 'spindle'
- ▶ OC 紡 *p^hjanX* < **p^hañ?*
- ▶ Mongsen Ao: *pañthəmɹu*
- ▶ Proto-Tani: **poŋ*
- ▶ ...

Archaeological evidence for spindle whorls

7000-5000 BC

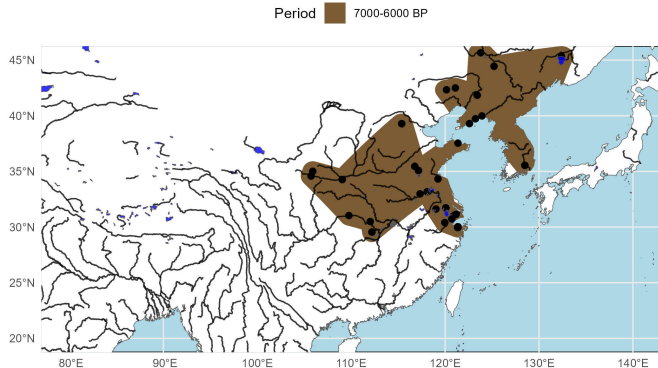
Buckley and Jacques (2025)



Archaeological evidence for spindle whorls

5000-4000 BC

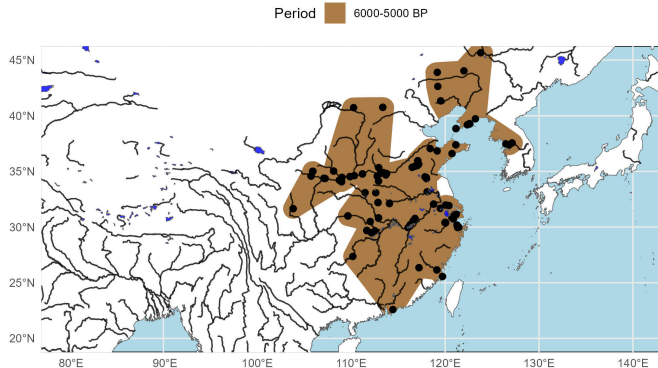
Buckley and Jacques (2025)



Archaeological evidence for spindle whorls

4000-3000 BC

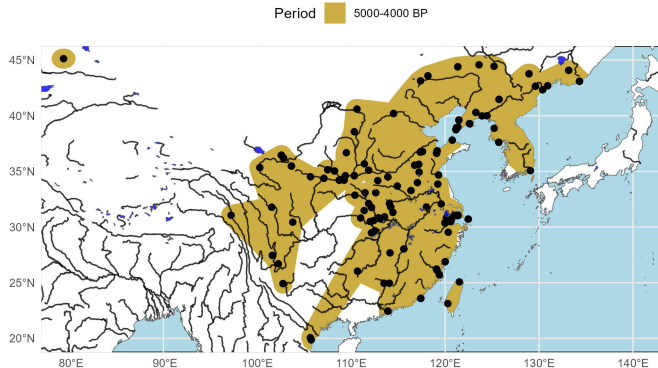
Buckley and Jacques (2025)



Archaeological evidence for spindle whorls

3000-2000 BC

Buckley and Jacques (2025)

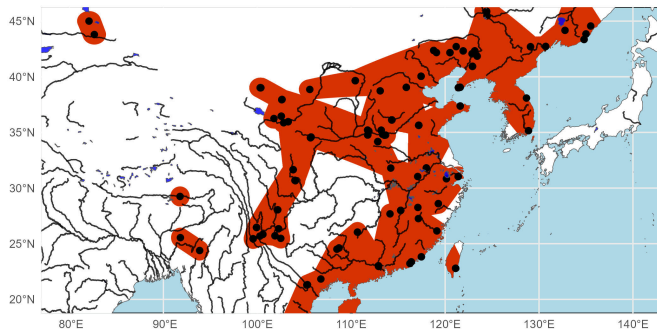


Archaeological evidence for spindle whorls

2000-1000 BC

Buckley and Jacques (2025)

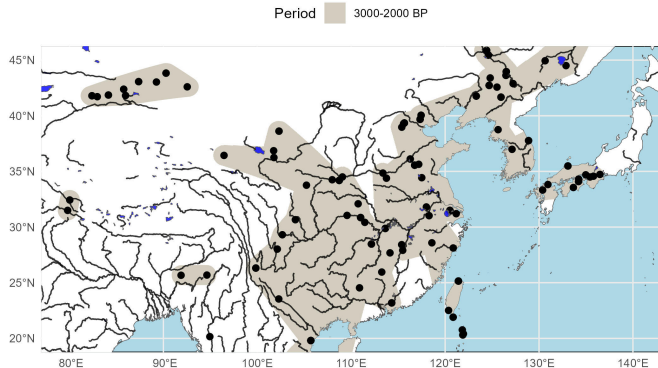
Period  4000-3000 BP



Archaeological evidence for spindle whorls

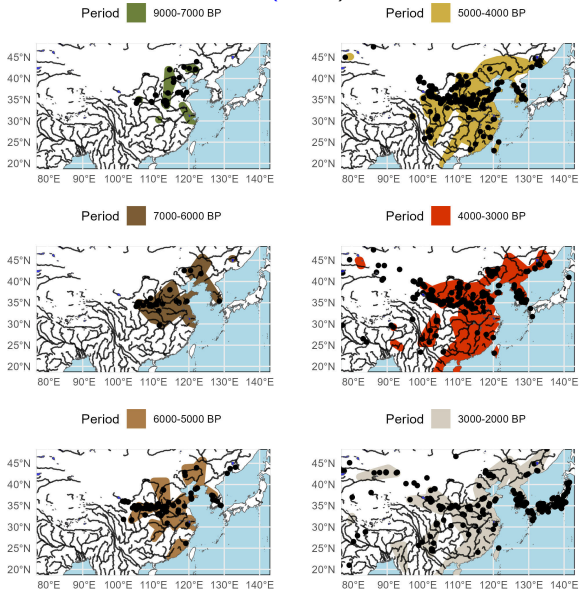
1000 BC-AD

Buckley and Jacques (2025)



Spindle whorls and millet agriculture

Jacques and Stevens (2024), Buckley and Jacques (2025)



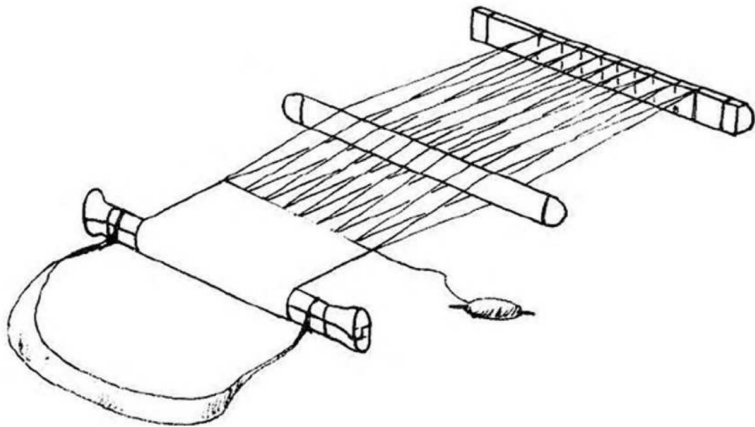
Archaeological evidence for looms

良渚反山遗址 ([Zhèjiāngshěng wénwù kǎogǔ yánjiūsuǒ, 2005](#))
(2900-2500 BC)



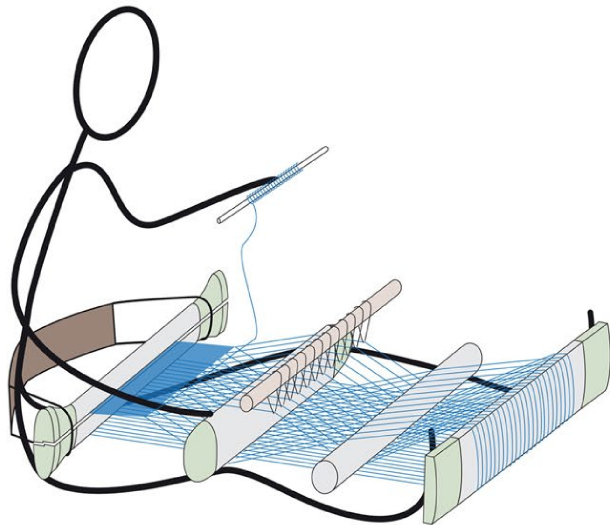
The Liangzhu loom

Reconstruction by Zhao Feng 赵丰 1992



The Liangzhu loom

Buckley (2023)



The Liangzhu loom

Buckley (2023):

“The beater, having blunt ends, is unsuited to picking out openings in the warp, implying that other means were used, most likely a heddle and shed-stick combination as shown in the reconstruction.”

Heddle



ɕnat 'Heddle'

u-sqar

Archaeolinguistics

Heddle

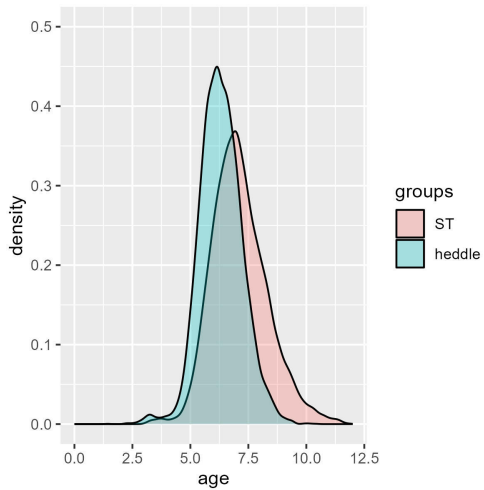
([Benedict 1972](#), 106 #436, STEDT #2491, [Matisoff 2016](#)).

- ▶ Japhug *ɕnat* ‘heddle’
- ▶ Tangut 𐰇𐰺⁵⁹⁷⁵ *nja*^{1.64}
- ▶ Tibetan སྒྲ་ *snas*
- ▶ Dulong *tsə*³¹*nət*⁵
- ▶ Jingpo *ɲiŋ*⁵⁵*nat*⁵⁵
- ▶ Kham *(o)-ne:h* ‘the leash strings on a heddle rod’ ([Watters, 2004](#))
- ▶ ...

Phylogenies

- ▶ Indo-European: [Gray and Atkinson \(2003\)](#); [Heggarty et al. \(2023\)](#)
- ▶ Austronesian: [Gray et al. \(2009\)](#)
- ▶ Sino-Tibetan: [Sagart et al. \(2019\)](#); [Zhang et al. \(2019\)](#)
- ▶ Kra-Dai: [Tao et al. \(2023\)](#)
- ▶ ...

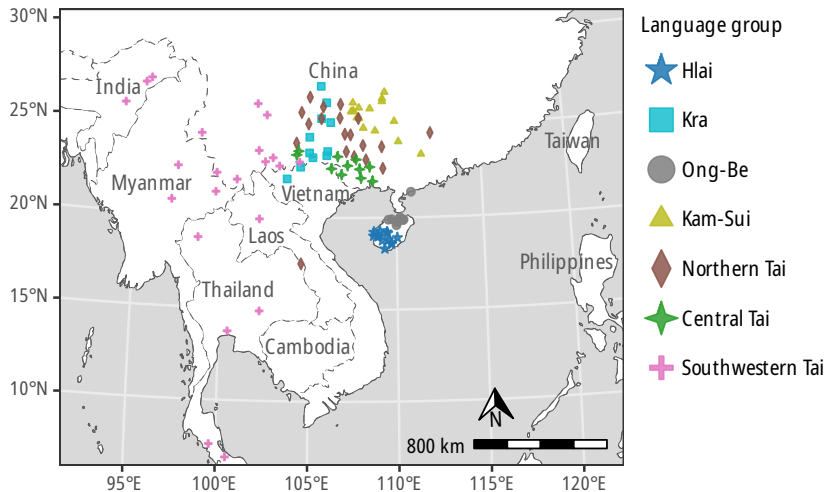
Date of MRCA



Phylogenies

- ▶ Indo-European: [Gray and Atkinson \(2003\)](#); [Heggarty et al. \(2023\)](#)
- ▶ Austronesian: [Gray et al. \(2009\)](#)
- ▶ Sino-Tibetan: [Sagart et al. \(2019\)](#); [Zhang et al. \(2019\)](#)
- ▶ **Kra-Dai**: [Tao et al. \(2023\)](#)
- ▶ ...

Dataset based on Tao et al.

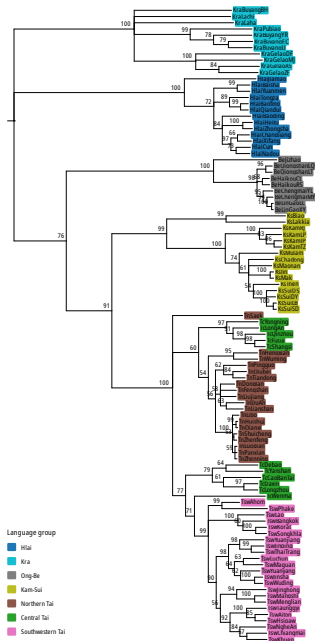


Cognate coding

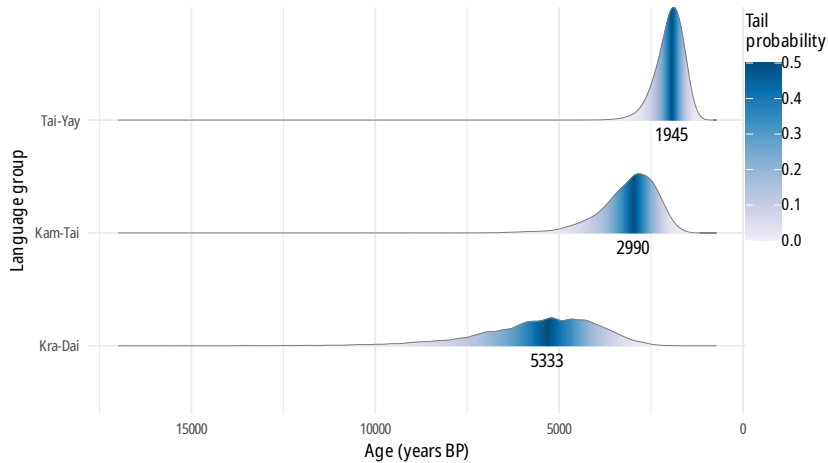
Buckley et al. (2025)

1. Basic vocabulary
2. Cognate coding based on regular sound correspondences
3. Exclusion of loanwords from Chinese (and between Kra-Dai languages, when these can be identified)
4. Use of the presence of Chinese loanwords in the reconstructible vocabulary from Chinese as evidence for the date of the MRCA of some subgroups.

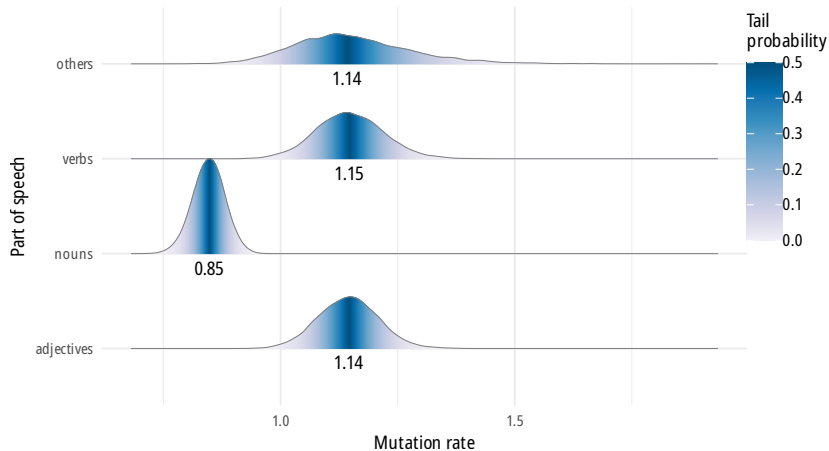
Consensus tree



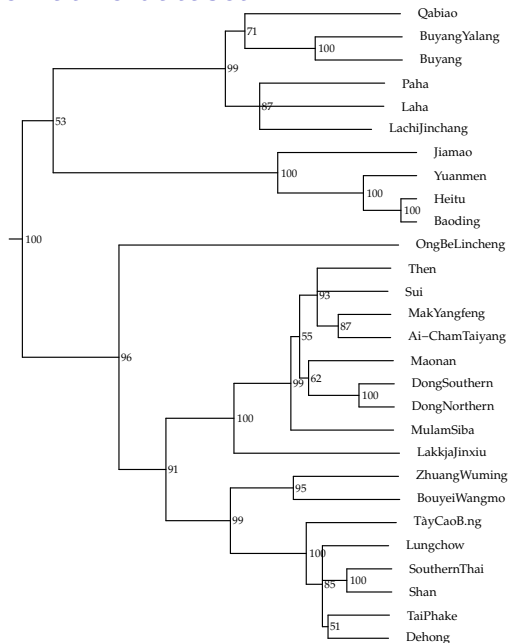
Age reconstruction



Mutation rates



Alternative dataset

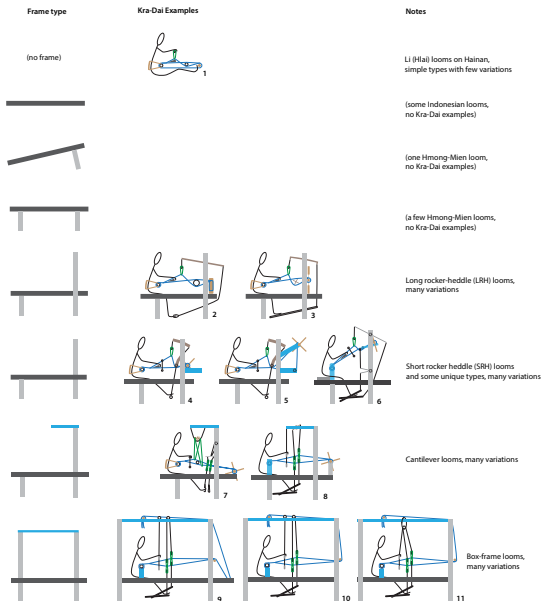


Loom phylogeny

1. Preliminary work on loom phylogenies: [Buckley and Boudot \(2017\)](#); [Boudot and Buckley \(2015\)](#)
2. The problem of the trait independence

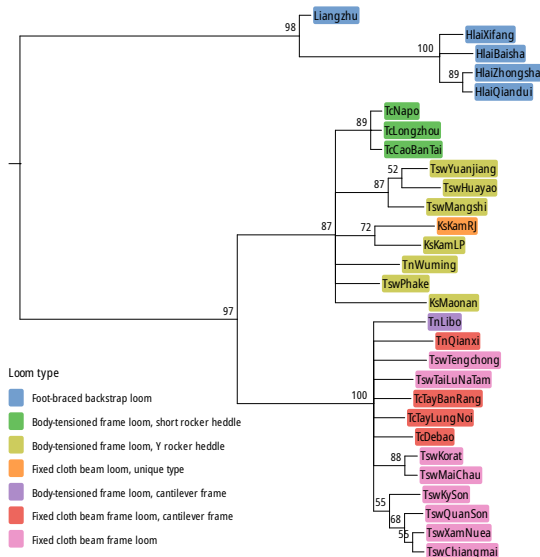
The evolution of looms

Buckley et al. (2025)



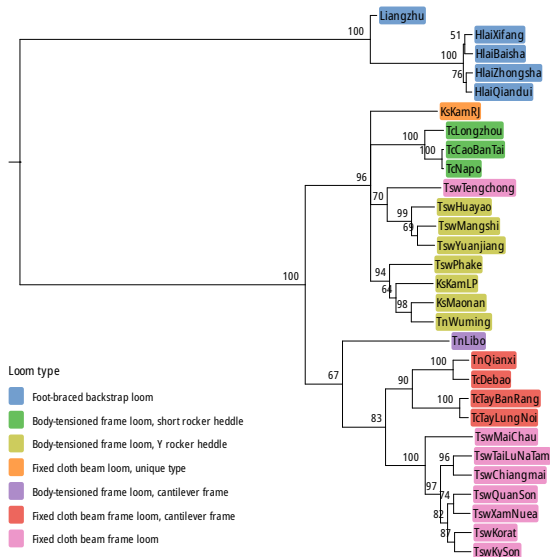
Loom phylogeny

Only levels 1 traits



Loom phylogeny

weights 1,1,1,1 for levels 1 to 4



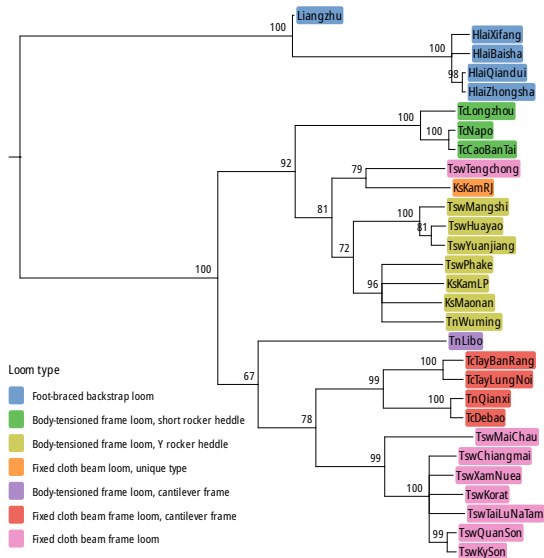
weights 8,4,2,1 for levels 1 to 4

Loom type

- Foot-braced backstrap loom
- Body-tensioned frame loom, short rocker heddle
- Body-tensioned frame loom, Y rocker heddle
- Fixed cloth beam loom, unique type
- Body-tensioned frame loom, cantilever frame
- Fixed cloth beam frame loom, cantilever frame
- Fixed cloth beam frame loom

Loom phylogeny

Basic loom structure traits

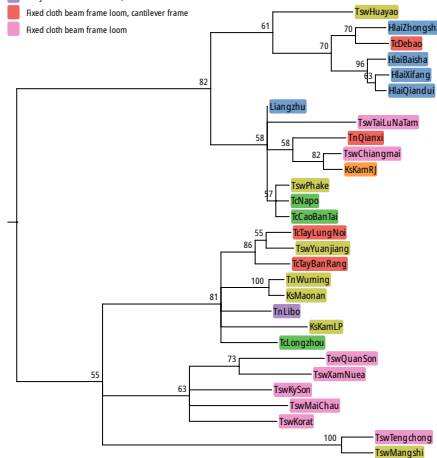


Loom phylogeny

Patterning traits

Loom type

- Foot-braced backstrap loom
- Body-tensioned frame loom, short rocker heddle
- Body-tensioned frame loom, Y rocker heddle
- Fixed cloth beam loom, unique type
- Body-tensioned frame loom, cantilever frame
- Fixed cloth beam frame loom, cantilever frame
- Fixed cloth beam frame loom



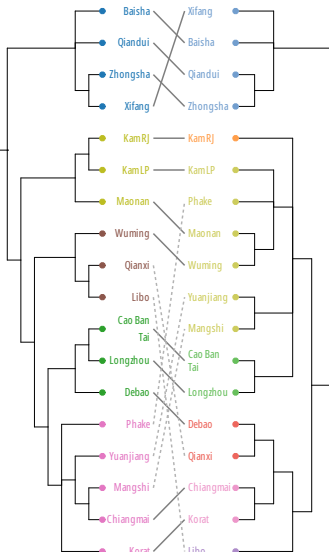
Loom phylogeny

1. The dependency between features has little impact on the topology
2. The phylogeny of patterning features has little relationship with the loom features

Cophylogeny

Language group

- Hlai
- Kra
- Ong-Be
- Kam-Sui
- Northern Tai
- Central Tai
- Southwestern Tai



Loom type

- Foot-braced backstrap loom
- Body-tensioned frame loom, short rocker heddle
- Body-tensioned frame loom, Y rocker heddle
- Fixed cloth beam loom, unique type
- Body-tensioned frame loom, cantilever frame
- Fixed cloth beam frame loom, cantilever frame
- Fixed cloth beam frame loom

Cophylogeny

1. Common outgroup: Hlai (languages) and foot-braced backstrap looms
2. Highly elaborate looms with fixed cloth beam frames associated with the Southwestern Tai group

Comparing the two phylogenies

1. PCA on the binary data at the leaves
2. [Blomberg et al.](#)'s K : the ratio of the observed variance explained by the phylogeny to the variance expected under a random model (values greater than 1 indicate strong phylogenetic signal)
3. Mapping the first component of the looms data onto the language trees: $K = 5.87$ ($p = 0.001$)
4. Mapping the first component of the linguistic data onto the looms trees: $K = 2.22$ ($p = 0.001$)

Language phylogeny explains a significant part of the variation in looms data (not taking into account the potential impact of geography)

References

- Benedict, Paul K. 1972. *Sino-Tibetan: A conspectus*. Cambridge: Cambridge University Press.
- Blomberg, Simon P., Theodore Garland and Anthony R. Ives. 2003. Testing for phylogenetic signal in comparative data 57(4). 717–745. doi: 10.1111/j.0014-3820.2003.tb00285.x.
- Boudot, Eric and Christopher D. Buckley. 2015. *The roots of Asian weaving. The He Haiyan collection of textiles and looms from Southwest China*. Oxford: Oxbow books.
- Buckley, Christopher D. 2023. The origins of southeast Asian weaving traditions: the perspective from archaeology. *Asian Archaeology* 7. 151–162. doi: 10.1007/s41826-023-00074-4.
- Buckley, Christopher D. and Eric Boudot. 2017. The evolution of an ancient technology. *Royal society Open science* 4(170208). doi: 10.1098/rsos.170208.
- Buckley, Christopher D. and Guillaume Jacques. 2025. Spindle whorls and the emergence of weaving in the east asia region. doi: 10.31235/osf.io/jgn47_v1.
- Buckley, Christopher D., Emma Kopp, Thomas Pellard, Robin J. Ryder and Guillaume Jacques. 2025. Contrasting modes of cultural evolution: Kra-Dai languages and weaving technologies. *Evolutionary Human Sciences* 1–28. doi: 10.1017/ehs.2025.10008.
- Gray, Russell, Alexei Drummond and Simon Greenhill. 2009. Language phylogenies reveal expansion, pulses and pauses in Pacific settlement. *Science* 323. 479–483.
- Gray, Russell D. and Quentin D. Atkinson. 2003. Language-tree divergence times support the Anatolian theory of Indo-European origin. *Nature* 426. 435–439.
- Heggarty, Paul, Cormac Anderson, Matthew Scarborough, Benedict King, Remco Bouckaert, Lechostaw Jocz, Martin Joachim Kümmel, Thomas Jügel, Britta Irlinger, Roland Pooth, Henrik Liljgren, Richard F. Strand, Geoffrey Haig, Martin Macák, Ronald I. Kim, Erik Anonby, Tijmen Pronk, Oleg Belyaev, Tonya Kim Dewey-Findell, Matthew Boutilier, Cassandra Freiberg, Robert Tegethoff, Matilde Serangeli, Nikos Liosis, Krzysztof Stroiński, Kim Schulte, Ganesh Kumar Gupta, Wolfgang Haak, Johannes Krause, Quentin D. Atkinson, Simon J. Greenhill, Denise Kühnert and Russell D. Gray. 2023. Language trees with sampled ancestors support a hybrid model for the origin of Indo-European languages. *Science* 381(6656). doi: 10.1126/science.abg0818.
- Jacques, Guillaume, Christopher D. Buckley and Shang Li. 2025. Weaving and loom terminology in Japhug. *Linguistics of the Tibeto-Burman Area* 48(1). 43–60.
- Jacques, Guillaume and Chris Stevens. 2024. Linguistic, archaeological and genetic evidence suggests multiple agriculture-driven migrations of Sino-Tibetan speakers from Northern China to the Indian subcontinent. *Quaternary International* 711(30). 1–20. doi: 10.1016/j.quaint.2024.09.001.
- Matisoff, James. 2016. Stedt database. URL <https://stedt.berkeley.edu/~stedt/cgi/rootcanal.pl>.
- Sagart, Laurent, Guillaume Jacques, Yunfan Lai, Robin J. Ryder, Valentin Thouzeau, Simon J. Greenhill and Johann-Mattis List. 2019. Dated language phylogenies shed light on the ancestry of Sino-Tibetan. *Proceedings of the National Academy of Sciences* 116(21). 10317–10322. doi: 10.1073/pnas.1817972116.
- Tao, Yuxin, Yuancheng Wei, Jiaqi Ge, Yan Pan, Wenmin Wang, Qianqi Bi, Pengfei Sheng, Changzhong Fu, Wuyun Pan, Li Jin, Hong-Xiang Zheng and Menghan Zhang. 2023. Phylogenetic evidence reveals early Kra-Dai divergence and dispersal in the late Holocene. *Nature Communications* 14(1). 6924. doi: 10.1038/s41467-023-42761-x.
- Watters, David E. 2004. *A dictionary of Kham, Taka dialect*. Kathmandu: Tribhuvan University.
- Zhang, Menghan, Shi Yan, Wuyun Pan and Li Jin. 2019. Phylogenetic evidence for Sino-Tibetan origin in northern China in the Late Neolithic. *Nature* 569. 112–115.
- Zhao, Feng 赵丰. 1992. 良渚织机的复原. 东南文化 2. 108–111.
- Zhèjiāngshěng wénwù kǎogǔ yánjiūsuǒ, 浙江省文物考古研究所. 2005. *Liángzhū yízhǐqún kǎogǔ bàogào zhīèr – Fānshān* 良渚遗址群考古报告之二. 反山 [Excavation reports on the group sites at Liangzhu, n°2 – Fanshan]. Beijing: Wénwù chūbǎnshè 文物出版社.