Sichuan Peppercorn and the Birth of Numbing Spices in East Asia

Guillaume Jacques[1*], Jade d'Alpoim Guedes[2]

[1]French National Centre for Scientific Research, Paris, France. [2]Department of Anthropology, University of California, San Diego, USA.

[*]rgyalrongskad@gmail.com

Abstract Sichuan peppercorn *Zanthoxylum* sp. is an important food condiment, currently used in East Asia and South Asia. In this paper, we review genetic, archaeological, and linguistic evidence regarding the use of *Zanthoxylum* by ancient human populations. The evidence from these three disciplines converge to suggest that its earliest attested use dates from the mid-fourth millennium BCE, in Western Sichuan, making it one of the oldest spices in East Asia. The paper also discusses how this spice was supplemented, and even superseded, by the introduction of the American Chili Pepper *(Capsicum spp.).* in the seventeenth century. We further argue that differences in the biosynthesis of numbing compounds between cultivars of *Zanthoxylum* sp. in northern and southern Western China that are due to deep evolutionary processes may have in turn influenced culinary preferences.

Received August 24, 2022
Accepted February 1, 2023
Published April 3, 2023

OPEN ACCESS
DOI 10.14237/ebl.14.1.2023.1842

Keywords *Zanthoxylum*, *Capsicum*, Majiayao, Spice, Rgyalrongic, Tibetic

Introduction

Prior to the introduction of black pepper (*Piper nigrum*) from India in the third century, and Chili Pepper (*Capsicum* spp.) from Mexico in the sixteenth century, local spices were considerably more prominent in the food preparation of people of East Asia than they have been in the last few centuries. Before the Han dynasty (202 BCE–220 CE), the main food condiments attested philologically and archaeologically were Sichuan peppercorn (*Zanthoxylum bungeanum*/*armatum*), ginger (*Zingiber officinale*) (Liu et al. 2022), angelica (*Angelica sinensis*) (Sheng et al. 2020) and Chinese cinnamon (*Cinnamomum cassia*), plants that were collected and eventually cultivated in areas within today's People's Republic of China, rather than introduced from the West.

From the point of view of linguistic evidence, although Old Chinese (the language corresponding to the texts written from 1300-200 BCE) and reconstructed proto-languages of comparable age in East Asia (proto-Hmong Mien, proto-Tai, proto-Rgyalrongic, proto-Lolo-Burmese) have words describing 'pungent/spicy' taste (in Old Chinese for instance 辛 *sin* ← **sin*), the exact taste it referred to in pre-Han China and neighboring areas was quite distinct from modern people's notion of *spicy*, which is essentially due to the wide availability of American Chili Pepper. Such a taste was unknown to ancient people of East Asia, and the exact meaning of these words in Old Chinese and proto-languages remains unclear.

In this paper, we focus on Sichuan peppercorn, the spice that is the best attested in the archaeological record and linguistic data. We review archaeological, genetic, and genetic data and propose a scenario on when *Zanthoxylum* was first cultivated and how it spread to the rest of East and South Asia, and what we can learn from it concerning ancient peoples' linguistic classification of flavors and spices.

Geographical distribution

The genus *Zanthoxylum* (Rutaceae) consists of 250 species worldwide, which includes 21 that are endemic to China (Zhang and Hartley 2008). Two different species are referred to as 'Sichuan peppercorn' (in Chinese 花椒 *huā jiāo*). The most common of these is *Zanthoxylum bungeanum*, which is endemic to China and is found in a wide range of habitats that are below 3200 meters in altitude and is currently distributed across the provinces of Fujian, Gansu, Guangxi, Guizhou, Hebei, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Liaoning, Ningxia, Qinghai, Shaanxi, Shandong, Shanxi, Sichuan, SE Xinjiang, S and SE Tibet, Yunnan, Zhejiang and in Bhutan (Zhang and Hartley 2008). Western China is the center of genetic diversity of this cultivar (e.g Feng et al. 2015, 2020).

The second one, *Zanthoxylum armatum* (in Chinese 竹叶花椒 ***zhúyè huājiāo*** 'Bamboo-leaf peppercorn'), is also, however, referred to as Sichuan pepper corn and used in a similar manner. This plant has a wider distribution and is found in habitats below 3100 m and is distributed in the provinces of Anhui, Fujian, Southern Gansu, Guangdong, Guangxi, Guizhou, Southern Henan, Hubei, Hunan, Jiangsu, Jiangxi, Shaanxi, Shandong, Southern Shanxi, Sichuan, Northern Taiwan, Xizang, Yunnan, Zhejiang [Bangladesh, Bhutan, India, Indonesia, Japan (including Ryukyu Islands), Kashmir, Ko rea, Laos, Myanmar, Nepal, Pakistan, Philippines, Thailand and Vietnam. Additional cultivars include *Z. piperatum* which is understood to have been introduced from Japan (Zhang and Hartley 2008). There are several key phenotypic differences between cultivars which correspond to genetic differences. For instance, *Zanthoxylum bungeanum* has (Red peppercorn 红花椒 ***hóng huājiāo***) red pericarps and *Zanthoxylum armatum* (Green peppercorn 青花椒 ***qīng huājiāo***) has green pericarps, deciduous and lanceolate leaves, and earlier flowering time as well as a distribution that is limited to Southwest China, which explains the latter. Feng et al. (2020) hypothesize that these two cultivated species, *Z. bungeanum* and *Z. armatum*, originated in Yunnan and Guizhou provinces during the Miocene and then dispersed to other regions via long distance dispersal events.

Genetics

Recent genetic studies have helped shed light on where these two populations of Sichuan peppercorn may have first been cultivated or domesticated (Feng et al. 2015, 2020). An analysis of SRAP markers from 175 wild and cultivated accessions found that red peppercorn accessions cluster within the *Z. bungeanum* complex, and green peppercorn accessions cluster within the *Z. armatum* (Feng et al. 2015, 2016). This study was limited, however, by the numbers of wild accessions they were able to access, which was restricted to specimens from Guizhou province. These wild specimens clustered closely with *Z. armatum*, suggesting that they were ancestral to the latter.

In a genome wide study, Feng et al. (2020) found that *Z. bungeanum* split into four geographic clades that spread across both subtropical and temperate China. They further infer a center of diversity in Gansu province, where samples from Wududahongpao (WDDHP) appears to be the ancestral population of *Z. bungeanum* from which other geographic clades arose. Two populations fell within the same clade as the ancestral variety in Gansu, which includes samples from Maowen in Sichuan (MWHJ) and a sample from Fengxian in Shaanxi. Each of these experienced very little genetic drift since their divergence from the common ancestor in Western Gansu. A second clade indicates multiple streams of Gansu to north gene flow including a series of back migrations that includes populations moving from Shandong to Shaanxi and Shanxi and back to Shandong. A final separate southwest China clade is represented by samples from Hanyuan in Sichuan (HYHJ), Qinlong in Yunnan (YXHJ) and Sajizhen in Guizhou (GZHJ). This last clade appears to have diverged prior to the common ancestor found in Gansu, but then experienced introgression from the Shandong and Shaanxi clades. In sum, this speaks to a center of diversity in Western China. Some cultivars also formed a separate clade with no genetic introgression either from the ancestral variety in Gansu or from later cultivars including HYDHP a sample from Hanyuan in Sichuan, suggesting that these varieties have been cultivated in relative genetic isolation throughout history (Feng et al. 2020). It is likely that these genetically isolated clades represent instances of cultivation of plants by farmers who did not exchange seeds with other areas following cultivation.

For *Z. armatum*, ancestral populations appear to have been located in frost free Southwest China (Sichuan, Guizhou, and Yunnan) (Feng et al. 2020; Hu et al. 2023). For *Z. armatum*, an analysis of divergence events showed that wild accessions of *Z. armatum* clustered together and possibly diverged from cultivated accessions ~3−5 kya BP (Feng et al. 2020).

Feng et al. (2020) also found that while there were high levels of genetic diversity within *Z. bungeanum*, there was little to no genetic diversity within

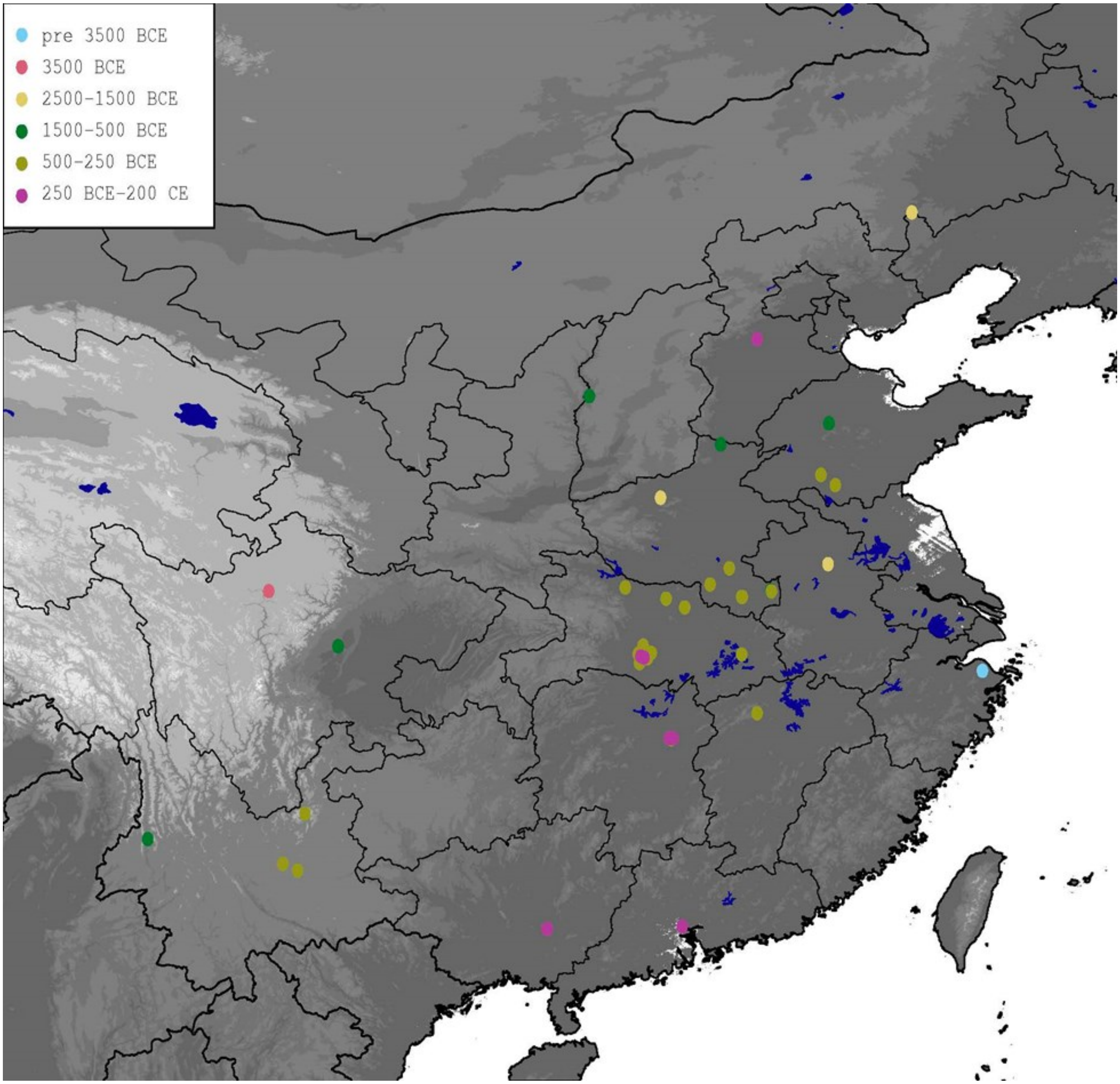

Figure 1 Early archaeological attestation of *Zanthoxylum* (see the complete dataset in the supplementary file peppercorn.xlsx)

individual cultivars. While on one hand this high level of genetic diversity within the species is reflective of high adaptiveness to local environments, the local diversity within cultivars is due to its special form of asexual reproduction. *Zanthoxylum* sp. reproduce via facultative sporophytic apomixis (Fei et al. 2021), a form of asexual reproduction that produces offspring without the need for combining male and female gametes, and where the offspring have the same genetic makeup as the mother. In sporophytic apomixis there is little to no exchange of pollen to the embryo and pollen is involved only in the formation of the triploid endosperm. Only occasionally does sexual reproduction happen in this plant and most individuals in the population samples by geneticists were clonal (Hu et al. 2023). It is hypothesized that this trait evolved as a suite of anti-herbivory linked traits during the Miocene (Hu et al. 2023). This contrasts with the co-evolution with pollinators in the example of many other angiosperms, where plants develop traits that encourage dispersal by pollinators. Hu et al. (2023) argues that these traits, alongside the biosynthesis of allomones and alkylamides evolved to deter insect herbivory, but also by extension insect pollination. We argue that the long-distance exchange of seeds (that contained genetic material that was identical to the mother plant) contributed to the high levels of genetic diversity seen within *Z. bungeanum* as cultivars adapted to local conditions as they spread geographically. However, once in place, farmers were able to retain high genetic fidelity within the plants they cultivated without the need for grafting (although they may have practiced this) due to *Zanthoxylum* sp.'s asexual form of reproduction.

Hu et al. (2018) and Feng et al. (2020) found that distinct regional demands for different cultivars reflect local idiosyncrasies in consumer tastes; for instance, the cultivars of *Z. bungeanum* distributed within the tropical and subtropical regions south of the Qinling Mountains contain more numbing components but fewer leaf glandular puncta, which likely evolved because of increased insect herbivory action in Southwest China, than those north of the Qinling, which also possess a lighter pericarp. Generally, selection processes for traits in sexually reproducing long generation perennials take many human generations and domestication traits are generally seen later in arboriculture than for annual plants, like grain crops (Fuller and Stevens 2019). This is because each plant produces genetically distinct seeds and each seed needs to grow to maturity until its traits are evident, thus requiring substantial selection over generations of farmers. We argue that despite *Zanthoxylum* sp. being a long generation perennial, the emergence of a new trait (such as more numbing components) could have easily been maintained in subsequent generations due to sporophytic apomixis. It is possible that the higher numbers of numbing components in *Z. bungeanum* south of the Qinling mountains was a random mutation that evolved in tandem with increased pressure from herbivory, but one that was easily maintained given this plant's form of reproduction. Humans in each area, thus, may have adapted their culinary tastes to the density of numbing compounds of *Zanthoxylum* in their area.

Sporophytic apomixis also makes *Zanthoxylum* an unlikely candidate to exhibit traits of domestication as asexual reproduction results in offspring that are identical to the mother plant. Indeed, there is little to no difference in flower type, seed size, or flowering uniformity between wild and cultivated varieties.

Archaeology

Archaeobotanical evidence makes it difficult to distinguish between the green and red varieties of *Zanthoxylum* as pericarps are often found in a carbonized form and color cannot be observed.

The earliest finds of *Zanthoxylum* sp. come from the Jingtoushan site in Zhejiang province which is dated to 6300-5800 BCE (Sun et al. 2021), but this isolated attestation is not followed by other finds in this area. Following this, *Zanthoxylum* sp. is found in Neolithic (Majiaoyao) layers in the Haxiu site in western Sichuan dating to roughly 3400-2900 cal. BCE (Zhijun Zhao: personal communication; Yáng et al. 2006). A radiocarbon date at Haxiu dates the site to 4470 ±30 BP (or 3340-3026 cal. BCE; d'Alpoim Guedes and Hein 2018). Finds then appear in Anhui at Yuhuicun 禹会村 by 2500 cal. BCE (Zhōngguó shèhuì kēxuéyuàn kǎogǔ yánjiūsuǒ Bèngbùshì bówùguǎn 2014), and then in the Shangtaizi 上台子 site in Inner Mongolia by roughly 2000 BC (Jia et al. 2017). Finds appear again at Jinsha 金沙 in the Chengdu plain by roughly 1400 BCE (Jiang et al. 2015) and again in Northern China (See Figure 1). Thus, by the second millennium BCE it appears that *Zanthoxylum* was already widely distributed across China.

Following this date, the numbers of finds increase substantially first across Northern China and Henan (Hénánshěng wénwù kǎogǔ yánjiūsuǒ 1986) and then finds center on Warring States period tombs in Hubei, where they appeared to have a prominent role as a spice in the Chu Kingdom, particularly in elite tombs (Sheng et al. 2020; Húběishěng wénwù kǎogǔ yánjiūsuǒ 1996; Yao and Xu 2008).

Figure 1 summarizes the sites dated BCE where *Zanthoxylum* remains have been discovered (the data on which this map is based can be found in supplementary Table 1).

Linguistics

Historical linguistics provides important evidence for the knowledge and use of plants and animals by past human societies, and Bayesian phylogenetic methods

Table 1 Etyma for *Zanthoxylum* in languages of the Austroasiatic, Hmong Mien and Kra-Dai families (Miáoyáoyǔ yánjiū shìbiān 1987).

Family	Branch	Language	Form
Austro-Asiatic	Vietic	Vietnamese	*sẻn ga*
	Khmuic	Khmu	*dʑɔŋ*
	Mangic	Mang	*pa^{31}ʔa^{51}*
	Angkic	Kemie	*ma^{31}khɛn^{35}*
	Pakanic	Bugeng	*lɯ̠ ^{24}*
	Palaungic	Wa (Masan)	*ʔa tɕhip*
		Wa (Yancheng)	*si giap*
		Wa (Aishuai)	*phiɔŋ*
Hmong-Mien	Hmongic	Qiandong	*so^{1}ka^{8}*
		Xiangxi	*ʂei^{37}*
		Chuanqiandian	*tsz^{3}ʂa^{3}*
		Diandongbei	*tsi^{6}sie^{3}*
		Baheng (Gundong)	*tjei^{22}ljaŋ^{22}si^{53}*
		Baheng (Wenjie)	*pe^{31}tɕɛ^{35}*
	Mienic	Mien	*huo^{2}tsiu^{1}* (From 花椒)
Kra-Dai	Kra	Laji	*min^{44}khje^{44}*

provide dated language phylogenies that can be compared with archaeological evidence (Sagart et al. 2019).

When several languages have similar words referring to a particular plant or animal, several hypotheses are possible: common inheritance, borrowing, parallel innovation, or chance resemblance. The study of *sound correspondences* and morphological structure can be used to identify inherited words and borrowings, and exclude chance resemblances, at least in the languages groups for which this knowledge is available. Distinguishing between very ancient nativized loanwords and inherited etyma can be difficult.

On the other hand, transparent compounds, even if they comply with regular sound correspondences, are not sufficient evidence for reconstructing an etymon, as they could have been coined independently in each language after the split of the proto-language.

In this section, we attempt to determine the earliest proto-language for which an etymon specifically referring to *Zanthoxylum* can be reconstructed, in order to infer the timeline of the use and management of this plant among ancient populations of East Asia.

Overview of the linguistic evidence

No less than five language families are spoken in areas where *Zanthoxylum bungeanum* or *Zanthoxylum armatum* are endemic: Sino-Tibetan, Hmong Mien, Kra-Dai, Austroasiatic and Indo-European. However, reconstructible terms for *Zanthoxylum* species have only been found in subbranches of Sino Tibetan, while terms attested in other families are either borrowed from Chinese or restricted to a particular subbranch.

In the following sections, we first present data from non-Sino-Tibetan families, then focus on Sino-Tibetan, and finally discuss one particular etymon attested in several subbranches of that family and its significance for the history of *Zanthoxylum* domestication.

Etyma referring to Zanthoxylum in non-Sino-Tibetan families

The natural range of *Zanthoxylum armatum* includes parts of South Asia where Indo-Aryan and Dravidian languages are spoken. However, no known term for *Zanthoxylum* is found in Sanskrit or any ancient language of South Asia.

Some Indo-Aryan languages use terms for *Zanthoxylum* that are etymologically transparent: for instance, Hindi ***tejphal*** '*Zanthoxylum*' is a compound from ***tej*** 'sharp' and ***phal*** 'fruit'. Such terms do not provide any evidence for ancient use and familiarity with this plant.

Another widespread form among languages of India is that represented by Nepali *ṭimur* '*Zanthoxylum*', which however is related to terms designating other plants (Sanskrit *tumburu-*, Pali *timbaru-* '*Diospyros embryopteris*' or '*Strychnos nux-vomica*', Turner 1966: 335), and which present irregular correspondences indicative of contact rather than inheritance.

In view of the early attestation of *Zanthoxylum* sp. in the Jingtoushan site in Zhejiang province (Sun et al. 2021), one could have expected that either Hmong-Mien, Kra-Dai or Austroasiatic languages (the three language families that potentially originate from the speech of the populations from the early Neolithic lower Yangtze) could have a reconstructible term for *Zanthoxylum* sp.

Yet, in Kra-Dai and Hmong-mien, we have no evidence for any native term for this plant, even though recent fieldwork reports provide detailed documentation of terms for cultivated and wild plants. In these two families, most languages use either borrowings from Chinese or trans parent compounds. Some languages even use the same word to refer to both *Zanthoxylum* sp. and *Capsicum* sp.: in Mak (Kra-Dai) for instance, both plants are designated by the word *lə^{2}seu^{1}* from Mandarin *làjiāo* 辣椒 'Chili Pepper'.

In Austroasiatic, native terms are found for *Zanthoxylum* sp., but they are unrelated across the family and there is no evidence that any etymon is reconstructible to even lower branches of Austroasiatic (Table 1).

Etyma referring to Zanthoxylum *in Sino-Tibetan*

The oldest philological attestation of *Zanthoxylum* sp. in any language comes from the Old Chinese poem 椒聊 *tsjew lew* 'The Pepper plant' from the 8th century BCE:

> (1) 椒聊之實、蕃衍盈升。彼其之子、碩大無朋。椒聊且、遠條且。 'The clusters of the Pepper plant, Large and luxuriant, would fill a pint, That hero there, Is large and peerless. O the Pepper plant! How its shoots extend!' (Translation by Legge)

The noun 椒 *tsjew* (reconstructed as *S.tew in Old Chinese by Baxter and Sagart 2014) was used to build the name of the Black Pepper (胡椒 *hújiāo*, etymologically 'barbarian *Zanthoxylum*') and Chili Pepper (辣椒 *làjiāo*, etymologically 'spicy *Zanthoxylum*'), following a new name was devised to refer to *Zanthoxylum* itself (花椒 *huājiāo* 'flowery

Table 2 Terms for *Zanthoxylum* in several subgroups of Sino-Tibetan

Group	Language	Zanthoxylum	Source
Sinitic	Old Chinese	椒 *tsjew* <*S.tew	(Baxter and Sagart 2014)
Kho-Bwa	Puroik	*sunuɛ̃*	(Lieberherr 2017)
	Tibetan Kurtöp	གཡེར་མ་ *gjer.ma chawa*	(Hyslop et al. 2022)
Bodic	'Olekha	*ço:*	Karma Tshering, Gwendolyn Hyslop (p.c.)
Sal	Jinghpo	*mă^{33}tʃa̱ŋ^{33}si^{31}*	(Huang 1992)
Guiqiong	Guiqiong	*tsá^{55}má^{55}*	(Huang 1992)
Nungish	Dulong	*a^{31}dʑap^{55}*	(Huang 1992)
Lolo-Burmese	Achang	*tɕap^{55}ʂə^{31}*	(Huang 1992)
Rgyalrongic	Khroskyabs	*rts^{h}áv*	(Lai 2017)
	Zhaba	*ʂtse^{31}shə^{55}*	
Para-Rgyalrongic	Smarskad	*jì.mjə̂*	Zhao Haoliang (p.c.)
Naish	Yongning Na	*dzeʎ*	(Michaud 2018)
Tujia	Tujia	*tsho^{55}pu^{55}*	(Huang 1992)
Idu-Kaman	Kaman	*tɕ^{h}ap^{53}*	(Li 2002)
Gongduk	Gongduk	*tshai*	Karma Tshering, Gwendolyn Hyslop (p.c.)

Zanthoxylum') to distinguish it from the two previous plants.

However, Old Chinese 椒 *tsjew* (**S.tew*) is unrelated to the name of plants belonging to this genus in other languages of the Sino-Tibetan family. Table 2 provides a representative sample of the forms found across the family, excluding branches where the term is borrowed from Indic, Chinese or Tibetan.

Four of these subgroups, Kaman, East Bodish, Nungish, Lolo-Burmese and Rgyalrongic, share similar forms to designate plants belonging to this genus. In the following, we analyze to what extent the resemblances between these forms are due to common inheritance, language contact, or chance, and what are the implications of these data for the history of the domestication of Sichuan Pepper.

These four subgroups are not particularly close to each other in the phylogeny of Sino-Tibetan. Table 2 illustrates the place of these four subgroups and their respective age according to Sagart et al.'s (2019) phylogeny of the Sino-Tibetan family.

Contact of inheritance?

The apparent resemblance one can observe between the Nungish, Lolo Burmese, Rgyalrongic and Kaman forms in Table 2 is strongly indicative of a historical relationship, but it remains to be shown

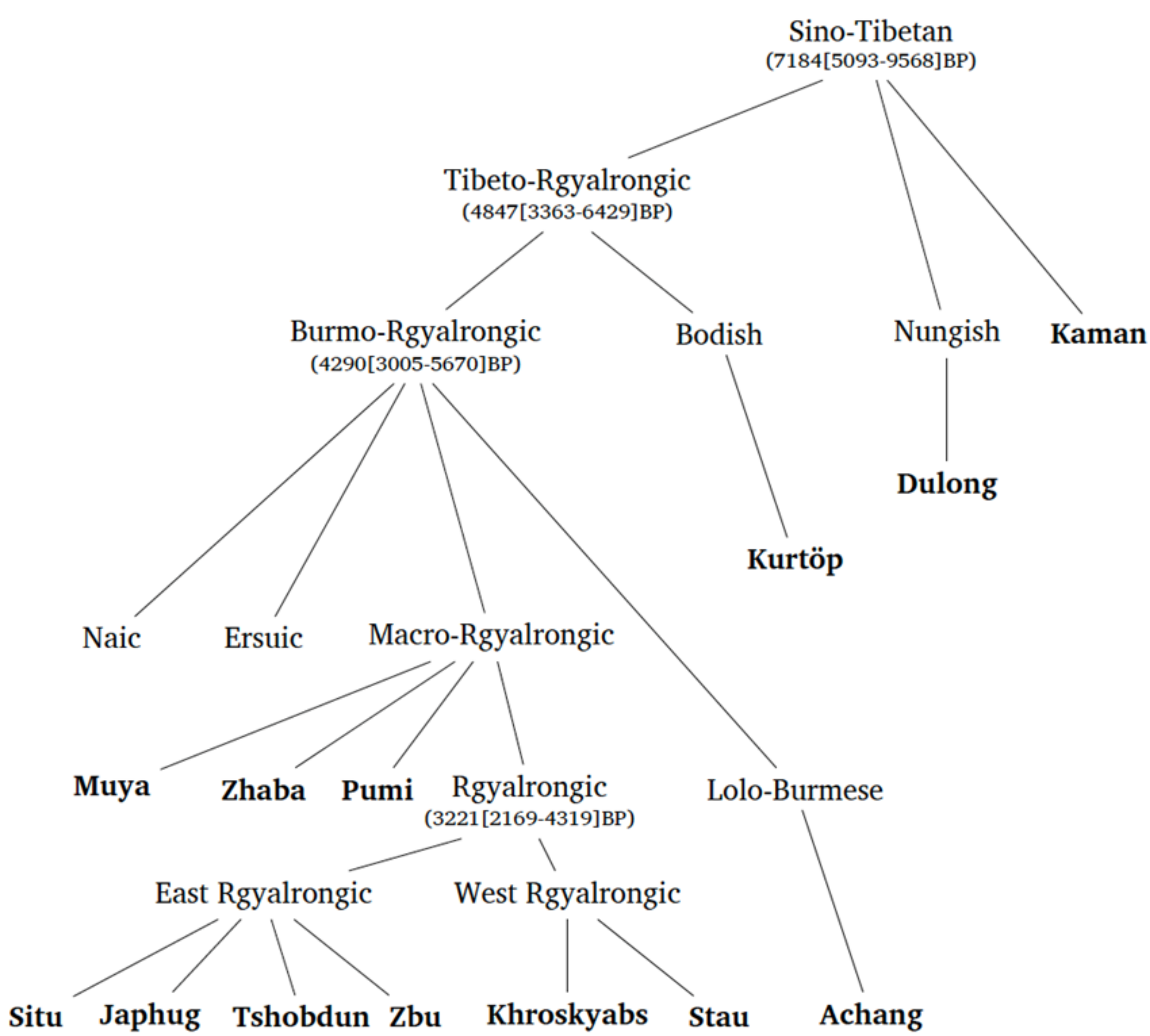

Figure 2 Simplified topology of the Sino-Tibetan phylogenetic tree (terminal nodes in bold). Tree topology and ages inferred are based on the relaxed-clock covarion model, data cited from Sagart et al. (2019). Branch length is irrelevant.

Table 3 Comparison of the etyma for '*Zanthoxylum*' and the verb 'be spicy' in Rgyalrongic languages.

Language	Zanthoxylum	'be hot, be spicy'	Source
Japhug	*(tɕɣom)*	*mɤrtsaβ*	
Situ (Bragbar)	*(mdzartsiɛ)*	*mərtsiɛp*	(Zhang 2020)
Situ (Cogtse)	*(mdzartsá)*	*martsáp*	(Lin 2016)
Khroskyabs	*rtsʰáv*	*rdzáv*	(Lai 2017)
Mazur Stau	*rtsʰɛv*	*rzɛv*	(Gates 2021)
Geshiza	*ltsʰəu*	*rzəu*	
Tangut	[illegible]512 *tsar1.80*	[illegible]45 *zar1.80*	(Honkasalo 2019)
Muya	*ze*^{13}	*tə*^{33}*dze*^{53}	
Zhaba	*ʂtse*^{31}*shə*^{55}		(Huang 1992)

whether this etymon reflects inheritance from the common ancestor of all these languages or borrowing between some of them.

In addition, we will see below, some Rgyalrongic and Lolo-Burmese languages have similar forms for the noun *Zanthoxylum* and the adjective 'be spicy', raising the question of their etymological relationship. In the following, we first discuss the data from the Rgyalrongic group, and show that the term for 'spicy' derives from the name of *Zanthoxylum*. Then, using sound correspondence, we argue that the similar forms found in Lolo-Burmese, and Kaman might reflect common inheritance, while the same is unlikely to be true for Dulong.

Rgyalrongic

Rgyalrongic languages are spoken in the Dkarmdzes and Rngaba districts of Western Sichuan, China (see Figure 3). They can be divided into two subbranches, Core Rgyalrong (Situ, Japhug, Tshobdun and Zbu) and West Rgyalrongic (Stau, Khroskyabs and the ancient language Tangut, Lai et al. 2020).

In West Rgyalrongic (see Figure 2) the term for *Zanthoxylum* presents an obvious resemblance with the adjective 'be spicy' (Table 3). The two etyma only differ by the voicing of the initial consonant and go back to ***rts(ʰ)æˠp¹*** and ***rndzæˠp¹*** in their common ancestor, respectively.[1] The semantic link between these two etyma and its significance for the history of taste classifications is discussed below.

The data in Table 3 show that both the noun '*Zanthoxylum*' and the verb 'be spicy' are reconstructible to the Macro-Rgyalrongic node. The noun '*Zanthoxylum*' is not found in East Rgyalrongic, but attested in West Rgyalrongic, Muya and Zhaba. From the point of view of sound correspondences, the first syllable of the Zhaba ***ʂtse***^{31}***shə***^{55} '*Zanthoxylum*' is phonologically compatible with Khroskyabs ***rtsʰáv*** '*Zanthoxylum*'. The historical phonology of Zhaba is very imperfectly understood, but we find the same onset correspondence in 'lung' (Khroskyabs ***rtsʰóz***, Zhaba ***ʂtse***^{55}***pe***^{55}) and the same rhyme correspondence in 'scoop water' (Japhug ***kaβ***, Zhaba ***tə***^{31}***khe***^{55}) and 'needle' (Japhug ***taqaβ***, Khroskyabs ***ʁâv*** and Zhaba ***je***^{55}). The second syllable ***-shə***^{55} is a suffix occurring in plant names. As for Muya ***ze***^{13}, the rhyme correspondence is ascertained by the Tibetan loanword ***the***^{53} 'method' (from Tibetan ***thabs*** 'method'), and the voicing of the initial is also found in nouns such as ***zə***^{53} 'shoe' (cognate of Japhug ***tɯ-xtsa*** 'shoe'). In East Rgyalrongic, the terms of '*Zanthoxylum*' are secondary. Situ *mdzartsá* '*Zanthoxylum*' is clearly analyzable: ***mdzar-*** is a radical that appears in the name of prickly plants such as ***mdzarwú*** (*Circium shansiense* Petrak.) and ***-tsa*** is a diminutive suffix (Zhang 2020:110).[2] This name, a possessive compound, which literally means '(plant having) small thorns', refers to the thorns of the *Zanthoxylum*. As for Japhug ***tɕɣom*** '*Zanthoxylum*', it appears to be related to the noun for ***smɯ-tɕɣom*** 'spark', possibly a metaphor about the fizzy oral sensation of this spice.

The etymological relationship between these two etyma raises the question of the directionality of derivation. Two hypotheses are possible:

1. Adjective to noun: 'the spicy (one)' → *Zanthoxylum*
2. Noun to adjective: *Zanthoxylum* → 'be spicy'[3]

The only way to decide between these two hypotheses is to take morphological alternations into account. Voicing alternations are found in Rgyalrongic, but only the directionality UNVOICED → VOICED (or voiced prenasalized) is attested (Gates et al. 2022). Since devoicing processes are not

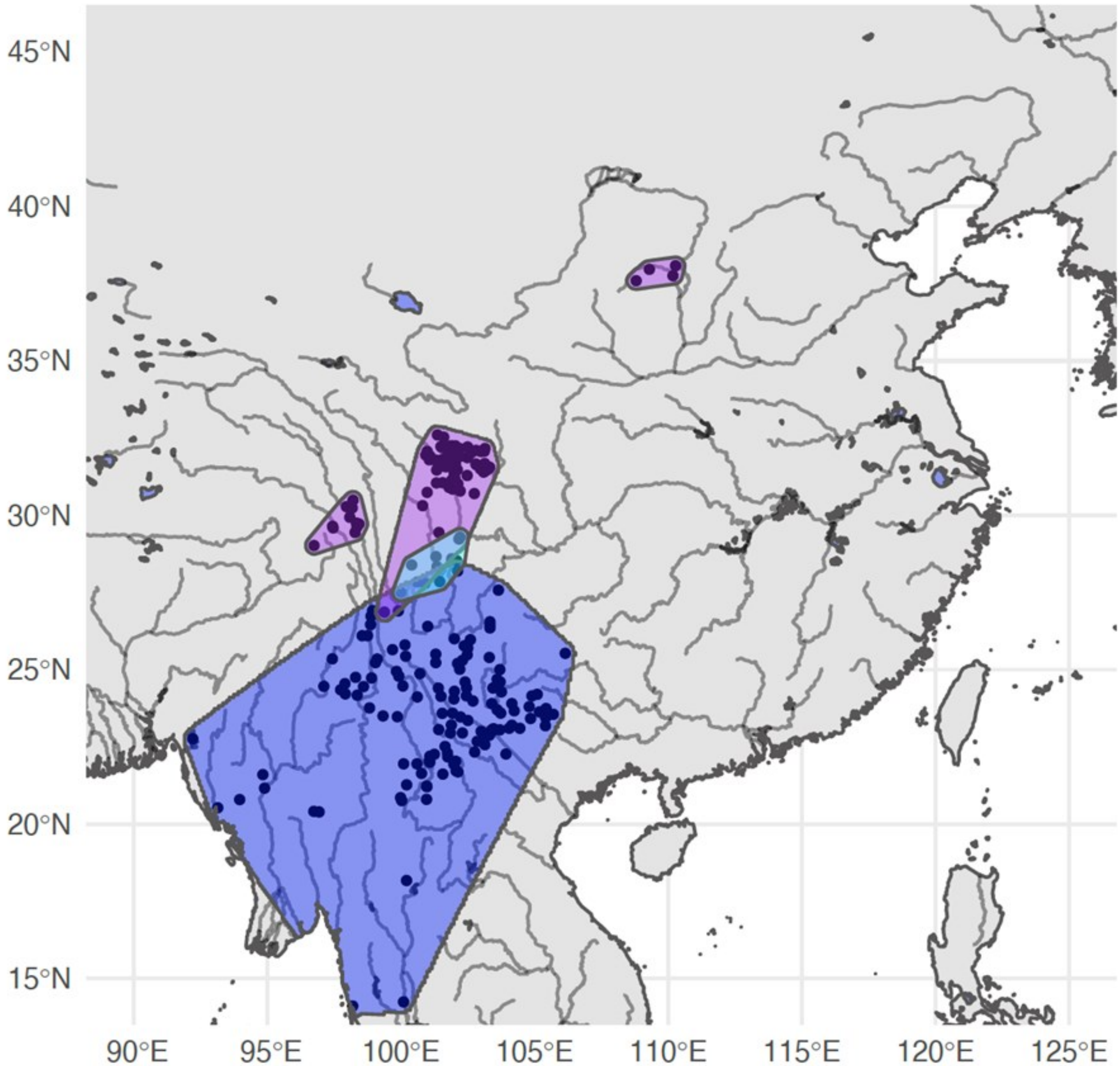

Figure 3 Burmo-Rgyalrongic languages (Purple: Rgyalrongic and para Rgyalrongic; Cyan: Naish and Ersuic; Blue: Lolo-Burmese).

otherwise attested, the adjective-to-noun hypothesis is extremely unlikely.[4]

Moreover, the source of voicing in the case of 'be spicy' reveals itself when comparing with East Rgyalrongic. East Rgyalrongic languages preserve presyllables lost in West Rgyalrongic (Lai et al. 2020), nasal presyllables induce onset voicing. Thus, proto-Khroskyabs ***rndzæˠp¹*** 'be spicy' can come from earlier ***N-rts(ʰ)æˠp¹***, where ***N-*** represents any nasal pre syllable. The ***mɤ-*** presyllable in Japhug ***mɤrtsaβ*** 'be spicy' and other East Rgyalrongic languages thus accounts for the voicing in West Rgyalrongic and can be analyzed as a ***mɤ-*** denominal prefix deriving intransitive verbs and adjectives (Jacques 2021:1044-1045).

Lolo-Burmese
The Rgyalrongic etymon ‘be spicy’ (pre-Khroskyabs ***N-rts(^{h})æ^{ɣ}p^{1}***, Japhug ***mɤrtsaβ***) directly corresponds to Burmese ***tsap*** ‘be spicy’, which could originate from either ****dzap*** or ****dʒap*** in proto-Burmish (Gong and Hill 2020). This proto-form is also compatible with the etyma for *Zanthoxylum* in several Burmish languages, including Zaiwa ***tʃap^{21}ʃi^{21}***, Achang ***tɕap^{55}ʂə^{31}***, reconstructed as ****dʒap-ʃeH*** (Gong and Hill 2020). In these nouns, the second syllable (for instance Achang ***ʂə^{31}***) means ‘fruit’, and they can thus be analyzed as compounds meaning ‘spicy plant’.

Achang ***tɕap^{55}ʂə^{31}*** ‘*Zanthoxylum*’ and related Burmish forms are not direct cognates of the Rgyalrongic etymon for ‘*Zanthoxylum*’ (pre-Khroskyabs ****rts^{h}æ^{ɣ}p^{1}***), but rather represent secondary compounds, built from the adjective ‘spicy’ (see the summary in Figure 4).

Nungish and Jinghpo
In Nungish, the terms for ‘Zanthoxylum’ are phonetically similar to the etymon ‘be spicy’ in Rgyalrongic and Burmish and have a voiced onset (Dulong ***a^{31}dʑap^{55}*** *‘Zanthoxylum’* and Rawang ***vzvp*** ‘*Zanthoxylum armatum*’ LaPolla and Sangdong 2015). Due to the discrepancy in voicing, these forms cannot be direct cognates of the Rgyalrongic etymon for *Zanthoxylum* and should rather be analyzed as early borrowings from the Burmish ‘spicy’ etymon, that took place before Burmish languages changed their voiced obstruents to unaspirated unvoiced stops.

Jinghpo, a language in contact with both Burmish languages and Dulong, does not have a related etymon for ‘*Zanthoxylum*’, but has the adjective ***tʃap^{31}*** ‘spicy’ (Huang 1992). This form is compatible with the correspondences of early Burmese loanwords into Jinghpo (Kurabe 2016), and in view of the fact that this etymon is not found in any of the languages that are phylogenetically closest to Jinghpo (Bodo-Garo, Northern Naga and Sak).

Bodish
The Tibetan word གཡེར་མ་ ***gjer.ma*** for *Zanthoxylum* is retained in most modern Tibetic languages (the languages descended from Old Tibetan). An exception is Dzongkha, a Tibetic language of Bhutan, where ***ema*** (from ***gjer.ma***) became the word for Chili Pepper (*Capsicum* sp.), and was replaced by ***thiŋŋe*** in the meaning *Zanthoxylum*, an etymon attested in Classical Tibetan as ***t^{h}iŋ.li*** referring to Pepperweed (*Lepidium latifolium)*, from Chinese 葶苈子 ***tínglìzǐ***.

While Tibetic etyma for *Zanthoxylum* are unrelated to the root found in Rgyalrongic, the East Bodish language Kurtöp has *chawa* ‘*Zanthoxylum*’ (Hyslop et al. 2022), whose first syllable could go back to earlier ****tɕ^{h}ap*** with a ****-(b)a*** suffix and intervocalic lenition. In polysyllabic Tibetan loanwords or cognates with -***ba*** as a second syllable, when the first syllable has a coda, it is lost in Kurtöp, and the consonant of the suffix is lenited to ***w***, as shown by examples such as ***phawa*** ‘Dhole, *Cuon alpinus*’ from Tibetan འཕར་བ་ ***^{n}p^{h}ar.ba*** or ***sawan*** ‘seed’ from Tibetan ས་བོན་ ***sa.bon***.

In this hypothesis, Kurtöp preserved the cognate of the Burmo-Rgyalrongic root for *Zanthoxylum*, while Tibetic languages (including Old Tibetan) lost it. In this verb, the etymon གཡེར་མ་ ***gjer.ma*** is an innovation, though its origin meaning is not known (the example of Dzongkha in again case leads credence to the idea that semantic shifts can occur with this plant name).

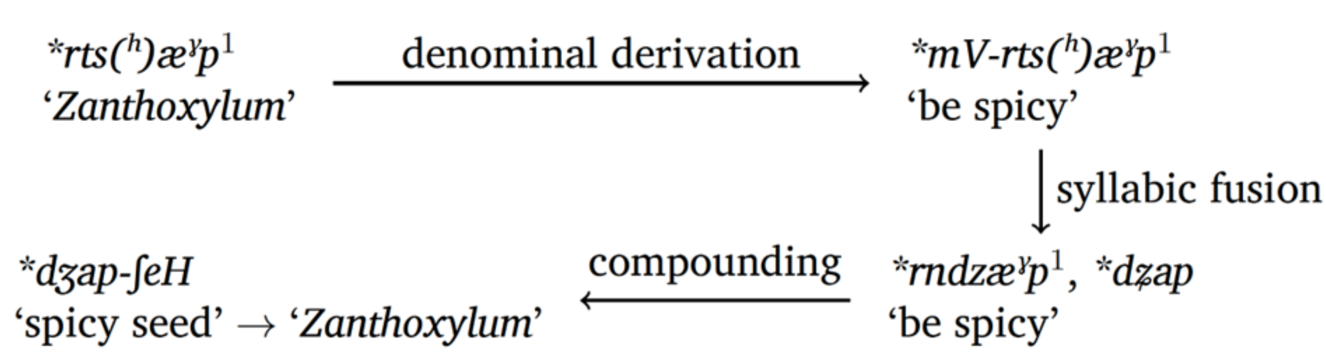

Figure 4 Derivational history of the etyma for ‘*Zanthoxylum*’ and ‘be spicy’ in Burmo-Rgyalrongic languages.

Kaman

Kaman ***tɕʰap⁵³*** ‘*Zanthoxylum*’ (Li 2002:258-259) appears to be phonetically compatible with the Rgyalrongic etymon for ‘*Zanthoxylum*’ (pre-Khroskyabs ****rts(ʰ)æˠp˥***). The historical phonology of Kaman has never been thoroughly investigated, and we lack any additional example of Rgyalrongic ****rts(ʰ)-*** corresponding to Kaman ***tɕʰ-***, but given the limited number of examples with this onset, this absence may be fortuitous.

Thus, the comparison of Kaman ***tɕʰap⁵³*** ‘*Zanthoxylum*’ with the previous etyma is plausible. Kaman is not in contact with Burmo-Gyalrongic languages, and unlike in the case of Nungish and Jinghpo, this etymon cannot be easily explained as a borrowing from Burmish. It could reflect inheritance from the common ancestor of Kaman and Burmo-Rgyalrongic, but this could entail a very early date. Another possibility is early borrowing from a non-Bodic languages (or from the ancestor of Tibetic, before the term གཡེར་མ་ ***gjer.ma*** ‘*Zanthoxylum*’ was innovated).

Zanthoxylum and spicy condiments

The etymological relationship between the noun *Zanthoxylum* and verb ‘be spicy’ discussed above is not entirely straightforward. The current meaning of the etymon ‘be spicy’ in Rgyalrongic languages (such as Khroskyabs ***rdzáv***) refer to the hot sensation of Chili Pepper, rather than the tingling and numbing oral sensation of *Zanthoxylum*, for which different terms are used. For instance, in Japhug, the taste of *Zanthoxylum* is *not* described by the adjective ***mɤrtsaβ*** ‘spicy’, but rather by the ideophonic verb ***ɣɤzɯβzɯβ*** ‘have the numbing taste of *Zanthoxylum*’.[5]

This discrepancy suggests that the meaning of the adjective ‘be spicy’ independently changed in all Burmo-Rgyalrongic languages in the last four centuries, following the introduction of Chili. Its original meaning must have rather referred to the oral sensation caused by *Zanthoxylum*, but when Chili replaced *Zanthoxylum* as the main food condiment due to its stronger oral sensation, speakers of Burmo-Rgyalrongic languages changed their understanding of the notion of ‘spicy’. Rather than coining a new word to describe this new flavor, they created new words to refer to that of *Zanthoxylum*, the older, but now secondary, condiment.

Summary of the linguistic evidence

The linguistic data reviewed in this section suggest that an etymon for *Zanthoxylum* is reconstructible to the common ancestor of Rgyalrongic, Lolo Burmese and Bodish, dated 4847 BP [3363–6429 BCE]) according to the main analysis of Sagart et al. (2019). It is possible that a cognate exists in Ka man. Although this language was not included in Sagart et al. (2019), the closely related languages Yidu and Taraon were, and the common ancestor of Rgyalrongic and Yidu-Taraon would go back to 6009 BP [4124–7834 BCE], very close to the root of the Sino-Tibetan family.

Outside of the Sino-Tibetan family, there is no evidence of reconstructible term for *Zanthoxylum* in any other language family, including the Kra-Dai, Hmong-Mien and Austroasiatic, the three families of Southern China and South-East Asia that are plausibly originate from the Neolithic population of the Lower Yangtze, where the earliest isolated attestation of *Zanthoxylum* has been found.

Conclusion

Archaeobotanical and genetic evidence converge to indicate that *Zanthoxylum* was employed by ancient populations in Western Sichuan at least in the fourth millennium BCE, before its use spread to the Central plains of China a millennium later. The mid-fourth millennium is slightly earlier than the approximate date of the common ancestor of Tibeto-Rgyalrongic, the earliest proto-language in which an etymon for *Zanthoxylum* is reconstructible, as shown by the evidence in this paper. Western Sichuan is also a fitting localization of the ancestral language of Tibetic and Rgyalrongic languages: the 哈休 Haxiu site where the earliest (although as of yet, not directly dated) evidence of *Zanthoxylum* was found is located in an area where the Rgyalrongic language Japhug is currently spoken. Incidentally, since the Chinese name Haxiu originates from Japhug ***ɬaɕɯ*** (whose etymology is unclear, though the first syllable is probably the Tibetan word ***lha*** ‘god’) an alternative name *Lhashu* based on Japhug could be used to refer to this site.

The linguistic evidence is thus compatible with the main conclusions of the other disciplines and supports the view that the earliest known use of *Zanthoxylum* could have been by millet farmer populations of Western Sichuan, around 5000 years ago, although evidence for its wider spread across Asia dates to later.

Although foragers inhabited Western Sichuan for millennia before the arrival of Neolithic farmers, and presumably would have been familiar with *Zanthoxylum*, there is no direct evidence that they used it for food consumption, and in any case, we have no trace of the languages they spoke. The isolated find of *Zanthoxylum* in the Jingtoushan site in the Lower Yangtze in the sixth-seventh millennium BCE reflects an independent early use of this plant. However, in view of the paucity of later evidence, and absence of linguistic support for ancient use of *Zanthoxylum* among people of Southern China, it may be a dead-end, reflecting discontinuity of use among these ancient populations.

The American domesticate Chili Pepper (*Capsicum* spp.) has served as a supplement or even a substitute of *Zanthoxylum* sp. after its introduction in East Asia from the seventeenth century, and has completely replaced it in many areas, to the extent that the original terms designating *Zanthoxylum* sp., formerly the main spice condiment, has been lost in many areas.

Notes

[1]No systematic reconstruction of proto-West Rgyalrongic has been proposed, but these reconstructions are based on Lai (2021). The Geshiza forms show an unexplained irregularity in the preinitials: ***r-*** would be expected in the noun ***ltsʰəu*** *'Zanthoxylum'*, perhaps a clue that this word has been borrowed from a closely related Gyalrongic language.

[2]Although the second syllable of Situ ***mdzartsá*** '*Zanthoxylum*' superficially resembles that of ***martsáp*** 'be spicy', no known morphological process could cause a final ***-p*** to disappear in word-final position in Rgyalrongic, and this resemblance is fortuitous.

[3]In English for instance, the adjectives 'spicy' or 'peppery' come from the nouns 'spice' and 'pepper', not the other way round.

[4]This hypothesis could only be supported if incontrovertible examples of onset devoicing are found in Rgyalrongic.

[5]In Chinese, the adjective 麻 ***má*** 'numbing' is used to describe this sensation.

Acknowledgments

Some of the fieldwork data has been obtained thanks to the project 'An Ethnobotanical Study of Rgyalrongic Languages' funded by The National Social Science Fund of China (19BYY190).

Declarations

Permissions: None declared.

Sources of funding: None declared.

Conflicts of Interest: None declared.

References Cited

Baxter, W. H. III, and L. Sagart. 2014. *Old Chinese: A New Reconstruction*. Oxford: Oxford University Press.

Fei, X. T., Y. Lei, Y. C. Qi, S. J. Wang, H. C. Hu and A. Z. Wei. 2021. Small RNA Sequencing Provides Candidate miRNA-target Pairs for Revealing the Mechanism of Apomixis in *Zanthoxylum bungeanum*. *BMC Plant Biology* 21(1):178. DOI:10.1186/s12870-021-02935-5.

Feng, S. J., Z. S. Liu, L. Chen, N. Hou, T. X. Yang and A. Z. Wei. 2016. Phylogenetic Relationships Among Cultivated *Zanthoxylum* Species in China based on cpDNA Markers. *Tree Genetics & Genomes* 12(45). DOI:10.1007/s11295-016-1005-z.

Feng, S. J., Z. S. Liu, Y. Hu, J. Y. Tian, T. X. Yang and A. Z. Wei. 2020. Genomic Analysis Reveals the Genetic Diversity, Population Structure, Evolutionary History and Relationships of Chinese Pepper. *Horticulture Research* 7(158). DOI:10.1038/s41438-020-00376-z.

Feng, S. J., T. X. Yang, Z. S. Liu, L. Chen, N. Hou, Y. Wang and A. Z. Wei. 2015. Genetic Diversity and Relationships of Wild and Cultivated *Zanthoxylum* Germplasms Based on Sequence-related Amplified Polymorphism (SRAP) Markers. *Genetic Resources and Crop Evolution* 1–12. DOI:10.1007/s10722-015-0222-x.

Fuller, D. Q., and J. S. Chris. 2019. Between Domestication and Civilization: The Role of Agriculture and Arboriculture in the Emergence of the First Urban Societies. *Vegetation History and Archaeobotany* 28(3):263–282. DOI:10.1007/s00334-019-00727-4.

Gates, J. 2021. *A grammar of Mazur Stau*: PhD dissertation, EHESS.

Gates, J, S. Honkasalo and Y.cF. Lai. 2022. From Transitive to Intransitive and Voiceless to Voiced in Proto-Sino-Tibetan: New Evidence from Stau, Geshiza, and Khroskyabs. *Language and Linguistics* 23 (2):208–236.

Gong, X. and N. W. Hill. 2020. Materials for an Etymological Dictionary of Burmish. https://zenodo.org/record/4311182# .YZ-GhDrjLRY.

d'Alpoim Guedes, J., and A. Hein. 2018. Landscapes of Prehistoric Northwestern Sichuan: From Early Agriculture to Pastoralist Lifestyles. *Journal of Field Archaeology* 43(2):121–135. DOI:10.1080/00934690.2018.1423830.

Honkasalo, S. 2019. *A Grammar of the Geshiza Language, a Culturally Anchored Description*: PhD dissertation, University of Helsinki.

Hu, L.cS., Z.cP. Xu, R. Fan, G.cY. Wang, F.cQ. Wang, X.cW. Qin, L. Yan, X.cZ. Ji, M.cH. Meng, S.cL. Sim, W. Chen, C.cY. Hao, Q.cH. Wang, H.cG. Zhu, S. Zhu, P. Xu, H. Zhao, K. Lindsey, H. Daniell, J. F. Wendel and S. X. Jin. 2023. The Complex Genome and Adaptive Evolution of Polyploid Chinese Pepper (*Zanthoxylum armatum* and *Zanthoxylum bungeanum*). *Plant Biotechnology Journal* 21 (1):78–96. DOI:10.1111/pbi.13926.

Hu, Y., L. Tian, J. W. Shi, J. Y. Tian, L. L. Zhao, S. J. Feng, and A.-Z. Wei. 2018. Genetic Structure of Cultivated *Zanthoxylum* Species Investigated with SSR Markers. *Tree Genetics & Genomes* 14(6): 89. DOI:10.1007/s11295-018-1300-y.

Huang, B. F. 1992. *Zàngmiǎn yǔzú yǔyán cíhuì* 藏缅语族语言词汇. Beijing: Zhōngyāng mínzú xuéyuàn chūbǎnshè 中央民族学院出版社.

Hyslop, G., K. Lhendrup, K. Tshering and P. Chhophyel. 2022. Kurtöp/English/Dzongkha Dictionary.

Jacques, G. 2021. *A Grammar of Japhug*. Berlin: Language Science Press. https://langsci-press.org/catalog/book/295.

Jia, X. 贾鑫, Y. G. Sun 孙永刚, J. G. Yang 杨金刚, and Z. J. Zhao 赵志军. 2017. Xīliáohé shàngyóu dìqū Xiàjiādiàn wénhuà shíqī fúx uǎn jiéguǒ yǔ fēnxī 西辽河上游地区夏家店文化时期浮选结果与分析 [The Analysis of Flotation Results of Plant Remains from the Upper West Liao River Region during Lower Xiajiadian Culture]. *Nóngyè kǎogǔ* 农业考古 6:33–39.

Jiang, M. 姜铭, X. Yan闫雪, and Z. J. Zhao 赵志军. 2015. Jīnshā yízhǐ jìsìqū zhíwù dàyícún fúxuǎn jiéguǒ jí fēnxī 金沙遗址祭祀区植物大 遗存浮选结果及分析 [Flotation Results and Analysis of Plant Remains in the Sacrifice Area of Jinsha Site]. In *Chéngdū kǎogǔ fāxiàn* 成都考古发现, 295–313. Kēxué chūbǎnshè 科学出版社.

Kurabe, K. 2016. Phonology of Burmese Loanwords in Jinghpaw. *Kyoto University Linguistic Research)* 35:91–128.

Lai, Y. F. 2017. *Grammaire du khroskyabs de Wobzi*. Paris: PhD dissertation, Université Paris III.

Lai, Y. F. 2021. The Complexity and History of Verb-stem Ablauting Patterns in Siyuewu Khroskyabs. *Folia Linguistica* 55(1):75–126.

Lai, Y. F., Xun, G., J. Gates and G. Jacques. 2020. Tangut as a West Gyalrongic Language. *Folia Linguistica Historica* 41(1):171–203.

LaPolla, R., and David S. 2015. *Rawang-English-Burmese dictionary*. Nanyang Technological University.

Li, D. Q. 李大勤. 2002. *Gémànyǔ yánjiū* 格曼语研究 *[A Study on the Geman language]*. Mínzú chūbǎnshè 民族出版社.

Lieberherr, I. 2017. *A Ggrammar of Bulu Puroik*: PhD dissertation, Universität Bern.

Lin, Y. J. 2016. *Jiāróngyǔ Zhuókèjīhuà yǔfǎ biāozhù wénběn* 嘉戎语卓 克基话语法标注文本 *[Cogtse Rgyalrong texts: Fully Analyzed Spontaneous Narratives with an Updated Sketch Grammar of the Language]*. Beijing: Shehui Kexue chubanshe.

Liu, L., J. Chen, J. J. Wang, Y. N. Zhao, and X. C. Chen. 2022. Archaeological Evidence for Initial Migration of Neolithic Proto Sino Tibetan Speakers from Yellow River Valley to Tibetan Plateau. *Proceedings of the National Academy of Science* 119(51). DOI:10.1073/pnas. 2212006119.

Michaud, A. 2018. *Na (Mosuo)-English-Chinese Dictionary*. Paris: Projet Himalco.

Miáoyáoyǔ yánjiū shìbiān, 中国民族学院苗瑶语研究室编. 1987. *Miáoyáoyǔ fāngyán cíhuì jí* 苗瑶语方言词汇集. Beijing: Zhōngguó mínzú xuéyuàn chūbǎnshè 中国民族学院出版社.

Sagart, L., G. Jacques, Y.-F. Lai, R. J. Ryder, V. Thouzeau, S. J. Greenhill, and J. M. 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

Sheng, P., H. Zhou, J. Liu and H. Jiang. 2020. Some Like it Hot: Sichuan Pepper (*Zanthoxylum bungeanum*) and Other Spices from a Late Bronze Age Kingdom (Chu State) in Hubei, China. *Archaeological and Anthropological Sciences* 12(249). DOI:10.1007/s12520-020-01201-3.

Sun, G. P. 孙国平, S. W. Mei 梅术文 , X.-J. Lu 陆雪姣 , Y. L. Wang 王永磊 , Y. F. Zheng 郑云飞, and W. J. Huang 黄渭金 . 2021. Zhèjiāng yúyáo shì jǐngtóushān xīnshíqì shídài yízhǐ 浙江余姚市井头山新 石器时代遗址 [The Neolithic site of Jingtoushan in Yuyao city of Zhejiang province]. *Kǎogǔ* 考古 (7):3–26.

Turner, R. L. 1966. *A Comparative Dictionary of Indo-Aryan Languages*. London: Oxford University Press.

Yao, Z. Y. 姚智远 and C.-F. Xu 徐婵菲. 2008. Xiān Qín liǎng Hàn huājiāo de yòngtú jí wénhuà yìyì 先秦两汉花椒的用途及文化意义 [The Usage of Sichuan pepper (*Zanthoxylum bungeanum*) and its Cultural Significance during the pre-Qin and Han dynasties]. *Nóngyè kǎogǔ* 农业考.

Yáng, W. C. 杨文成, T.-C. Dài 代堂才, F. Y. Dài 代福尧 , J. Chén 陈剑 , X Z. Chén 陈学志, Y.-G. Fàn 范永刚, and X. Yáng 杨昕. 2006. Sìchuān Mǎěrkāng xiàn Hāxiū yízhǐ 2003-2005 nián diàochá jiǎngào 四川马尔康县哈休遗址2003-2005年调查简报. *Chéngdū kǎogǔ fāxiàn* 成都考古发现 1–14.

Hénánshěng wénwù kǎogǔ yánjiūsuǒ, 河南省文物考古研究所 (ed.). 1986. *Xìnyáng Chǔ mù* 信阳楚墓 *[The Chu tombs at Xinyang]*. Wénwù chūbǎnshè 文物出版社.

Húběishěng wénwù kǎogǔ yánjiūsuǒ, 湖北省文物考古研究所 (ed.). 1996. *Jiānglíng Wàngshān Shāzhǒng Chǔ mù* 江陵望山沙塚楚墓 *[The Chu Tomb at Wangshan and Shazhong, Jiangling]*. Beijing: Wénwù chūbǎnshè 文物出 版社.

Zhang, D. X. and T. G. Hartley. 2008. *Zanthoxylum* Linnaeus. In Zhengyi Wu and Peter Hamilton Raven (eds.), *Flora of China* vol. 11:52–53. Beijing: Science Press.

Zhang, S. Y. 2020. *Le dialecte de Brag-bar du rgyalrong situ et sa contribution à la typologie de l'expression des relations spatiales: le mouvement associé et l'orientation*. Paris: PhD dissertation, Inalco.

Zhōngguó shèhuì kēxuéyuàn kǎogǔ yánjiūsuǒ Bèngbùshì bówùguǎn, 中国 社会科学院考古研究所、蚌埠市博物馆 (ed.). 2014. *Bèngbùshì Yǔhuìcūn* 蚌埠市禹会村 *[The Yuhui site in Bengbu]*. Kēxué chūbǎnshè 科学出版社.