A phonetic study of Sui consonants and vowels

Jerold A. EDMONDSON
University of Texas at Arlington

John H. ESLING, Jimmy G. HARRIS
University of Victoria

James WEI
Beijing, China

1. Introduction

The Sui people belong to the Kam-Sui language grouping of Guizhou and Guangxi Provinces[1]. They have a population of 346,000 according to the 1990 census, but the Sui language has an importance far beyond its size. It was the landmark investigations of Sui in the 1940s that proved a connection between Thai and languages of SW China. One important discovery made during this work was that the Sui language had preserved an inventory of sounds relatively rich and archaic in comparison to Tai groups of SE Asia. Aside from its historical importance for the Kam-Tai language grouping, Sui also contains some interesting phonetic features that will be discussed below.

But Sui language and culture is much more than just a cornucopia of archaisms. Sui perpetuates still today a vibrant and varied lifestyle in Sandu Sui (Shui) Autonomous County of Guizhou Province and in the nearby counties of Libo, Dushan, Fuquan, and Rongjiang. Indeed, ninety-three percent of the Sui population (322,000 people) resides in Guizhou Province, China with an additional 10,000 living in Guangxi-Zhuang Autonomous Region to the south. A small number people of Sui migrated some decades ago to Fuyuan County in Yunnan Province and some Sui families left eight generations ago for Vietnam where 120 still live today in Hồng Quang District of Tuyên Quang Province. But it is in Guizhou at Sandu Sui Autonomous County in Qiannan

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Prefecture where the Sui population is most densely settled and which the Sui people rightly regard as their cultural and linguistic center.

Sui people make up one element of a complex of Kam-Tai peoples with whom they share a common history and many common cultural practices. The closest linguistic relatives of the Sui are, perhaps, the Maonan (population 90,000) who live to the south and west of them at Huanjiang County in Guangxi Province. Other language groups in this same branch are Mak and T'en. And, just to the east of Sandu County are found the Kam, the largest member of the Kam-Sui sub-branch (population 2.5 million). In Chinese annals and historical books it states that Kam-Tai people originated from the ancient Yue people, who covered a large area in South China up to about 700 BC and who are accorded the ancestors of all the Kam-Tai people. Some scholars have suggested that Sui people are directly descended from one branch of the Yue called the Luoyue. There are today vestiges of common cultural practices of the Kam-Tai peoples in the shared vocabulary. For instance, Sui and the other Kam-Sui languages have cognate vocabulary and customs associated with wet paddy rice farming, e.g. *qui*^{2} 'water buffalo', *ʔau*^{4} 'rice', *ʔdoŋ*^{3} 'winnowing basket' and *taap*^{7} 'carrying pole' as well as with marriage practices. Among Kam-Sui peoples it was until some decades ago customary that a woman marry her father's sister's son (cross-cousin marriage). Some have suggested that cross-cousin bonds reflect an original clan-based social organization with compact communities and villages typically of a few hundred related by bloodlines. These villages in mountain valleys and hollows are usually located near rivers and even today display the stilted wooden house style.

The Sui people call themselves *ʔai*^{33} *sui*^{33}. The first element is a classifier element meaning ' (male) person' and occurs widely in compounds with this interpretation. The origins of the autonym *sui*^{33} are more obscure. It has been suggested that Sui might refer to 'water' in light of the propensity of the Sui people to settle near riverbanks. But this account seems flawed, as many other Tai and Kam-Sui groups have riverine cultures and, even more importantly, the Sui word for 'water' is *nam*^{3}, and does not resemble closely *Shui* or *Sui*, meaning water in the Han or the Chinese language. To date no convincing account of the meaning of *sui*^{33} has emerged.

The Sui language is relatively homogenous from place to place and it is the common vernacular among people living in Sui areas, as many people from other ethnic groups residing together with the Sui also can speak Sui. Just about everyone also can speak some form of local Chinese vernacular, as well. When Sui people live among other groups, only a few have given up their first language and adopted Chinese. These observations all testify to a strong tradition of language maintenance among the Sui people.

2. Previous studies of Sui

The name first linked with the study of the Sui language is that of Professor Li Fang Kuei who did research on Sui in 1942 in two villages called Li and Ngam in Libo County of Guizhou Province. The standard phonological analysis of Sui since has been closely related to that of Li. In Li's analysis there is a series of labial and dental stops, which are unaspirated, aspirated, voiced, and preglottalized /p t ph th b d ʔb ʔd/. There is also a series of labial, dental, prepalatal, and velar nasals, which are voiceless, voiced, and preglottalized /m̥ m ʔm n̥ n ʔn ɲ̊ ɲ ʔɲ ŋ̊ ŋ ʔŋ/. It has four affricates /ts tsh tɕ tɕh/. Sui also has uvular and velar stops /k kh q qh/; the uvulars do not occur in Tai languages. It has five approximants /l w ʔw j ʔj/, nine fricatives /f s z ɕ x ɣ ʔɣ ʁ h/, and glottal stop /ʔ/. All syllables begin with at least one of these consonants.

The dentals including the sibilant affricates and the sibilant fricatives, the labials, and the lateral can be followed by /j/, resulting in the following clusters /pj phj bj ʔbj mj fj wj tj thj dj ʔdj nj ʔnj n̥j lj tsj tshj sj zj/[2]. Four of the velars /k kh ŋ̊ ŋ/ can be followed by /w/ forming the following clusters /kw khw ŋ̊w ŋw/. Phonologically, the only consonants that can occur finally in a syllable are /-m -n -p -t -k/.

In a later statement of the Sui sound system, Li (1977b:4-5), there are six vowels /a e o i u ə/ with /a/ capable of being long /a/ or short /ă/ contrastively. The diphthongs he lists are /ăi ai oi ui ău au eu iu/. Li's tonal system consists of six contrastive pitch trajectories he reports as: Tone 1 low level or 11 in Ngam and low rising or 13 in Li; Tone 2 is low falling or 31; Tone 3 is mid level or 33; Tone 4 is high falling or 53; Tone 5 is mid high rising or 35; Tone 6 is high level or 55. He states syllables ending in /-p -t -k/ have Tones 4 or 5.

The next important work on Sui was the Chinese language dialectology study Shuiyu diaocha baogao (SDB) (1956) produced and conducted by a group of sixteen native speakers ranging in age from 17 to 46. Fifteen were men and one was a woman. The results of the study were submitted to higher authority but never officially published. In their report nine locations were investigated, some locations consisting of more than one village. Of these locations all but two were found in Sandu Sui Autonomous County, Guizhou Province; one location was found in Rongjiang Kam Autonomous County to the east, and one was located in Dushan County to the west. This investigation did not include the locations studied by Professor Li, as Sandu County, just to the north of Libo County, by this time was recognized as the linguistic and cultural heartland of the Sui people. The nine locations studied by the group showed very similar tonal systems, which they recorded as follows:

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[2]The second element of the cluster listed by Li /j/ represents a short [i]-like off-glide of the initial consonant. In Zhang Junru's statement of Sui phonology, collected in Wang (1984:513-514), the initials /tsh tshj tsw tshw/ only occur in contemporary Han loanwords.

Table 1. Tone values reported in SDB (1956) for nine Sui locations

	Sandong	Zhonghe	Jiuqian	Yaoqing	Hengfeng	Shuilong	Pandong	Rongjiang	Yang'an
1	13	13	13	13	12	13	13	13	13
2	31	31	31	31	31	31	31	31	31
3	33	33	33	33	33	33	33	33	33
4	53	53	53	53	42	53	53	42	53
5	35	35	35	35	35	35	35	34	35
6	55	24/55	55	55	24/55	24/55	55	55	24/55
7S	5	5	5	5	5	45	5	5	5
7L	35	35	35	35	35	35	35	34	35
8S	43	32	42	43	42	32	42	32	21
8L	42	31	53	53	31	31	31	32	31

In this listing it is noteworthy that Tone 6 demonstrates two differing tone shapes in the locations Zhonghe, Hengfeng, Shuilong, and Yang'an. SDB (1956:24) reports that native Sui words with Tone 6 show a 24 pitch shape and new Han loanwords with Tone 6 have a 55 pitch shape. Regarding the tone categories 7S, 7L, 8S, and 8L, Chinese scholars generally distinguish original long closed syllables from original short closed syllables. Those labeled 7S and 8S had such short vowel nuclei, whereas those labeled 7L and 8L had long vowel nuclei. Today these vowel length differences have mostly been displaced to a contrast of pitch for all vowels except /a/.

The maximum overall consonant system in the Sui dialectology study (SDB 1956) was identical with Professor Li's system except for two additional voiced velar oral stops /g ʔg/ that contrast with voiced velar fricatives /ɣ ʔɣ/. The symbols /ȶ ȶh/ were substituted for the IPA /tɕ tɕh/ to distinguish them from the Modern Standard Chinese (MSC) /tɕ tɕh/, which must have [i]-like or [y]-like off-glides in the MSC phonetic system. The symbols /v ʔv/ were used to represent both the labial-velar approximant [w] and the labiodental approximant [ʋ]. According to SDB the /f/ represents [f] or [ɸ]. The /b d/ voiced oral stops represent prenasalized voiced stops [ᵐb ⁿd]. The prenasalized voiced stops have a very short prenasalization onset. The voiced prenasalized oral stops [ᵐb ⁿd] always occur in vocabulary exhibiting one of the historical high tones. In at least three of these locations recorded in the SDB 1956 dialectology study, the preglottalized series, both stops and nasals have merged with plain nasals or stops. The voiceless nasal and approximant series have merged with their corresponding plain counterparts. The overall phonological system of SDB (1956: 23-4) was:

Table 2. Sui overall consonant system from SDB (1956)

p	ph	mb	ʔb	m̥	ʔm	m	f	v	ʔw
t	th	nd	ʔd	n̥	ʔn	n		l	
ts	tsh						s	z	
tɕ	tɕh			ɲ̊	ʔɲ	ɲ	ɕ	j	ʔj
k	kh	(g ʔg)		ŋ̊	ʔŋ	ŋ	x	ɣ	ʔɣ
q	qh	(ɢ)						ʁ	
ʔ							h		

This consonant chart is virtually identical to Li (1948: 160) with additional sounds written between parentheses, which are derived from the SDB (1956) standard overall phonological system. This overall system covers the phonology statements made in subsequent works such as Zhang Junru (1980), Zeng Xiaoyu and Yao Fuxiang (1996), and Wei and Edmondson (2003). The system presented in Table 2 is based on the speech of Sandong Village, Sandu County, Guizhou Province and is said to be representative of 90% of all Sui speakers.

3. Our research on Sui

Our research on the phonetics of Sui consonants and tones has added some new insights into the phonetics of Sui. The dentals such as initial [t th] are, in fact, dentals with a wide postdental contact area. The tongue tip is in contact with the lingual surface of the upper central incisors and at the same time the blade of the tongue is in contact with the front part of the alveolar ridge. These sounds are actually denti-alveolar (apico-dental laminoalveolar). The same places of articulation are commonly true for the affricates [ts tsh]. The initial preglottalized [ʔd], the preglottalized nasal [ʔn], the lateral [l], and the final double articulation [-͡ʔt] are frequently apico-alveolar with places of articulation that can range back to the posterior part of the alveolar ridge. The prepalatal affricates [tɕ tɕh] have a place of articulation that covers both the post-alveolar zone and the prepalatal zone simultaneously and are actually alveolo-palatals made with the blade of the tongue and the extreme anterior portion of the front part of the dorsum. The Sui alveolo-palatal affricates do not have the [i]-like or [y]- like offglides that the prepalatal affricates of Han Chinese [tɕ tɕh] always have. The Sui alveolo-palatal affricates are more like those of Standard Thai, cf. Harris (1972) and Tingsabadh and Abramson, A. S. (1999).

In 1943, Li Fang Kuei described two different kinds of preglottalized voiced stops in Tai languages (Li 1943: 178-179). The first type of preglottalized stop Li called a strongly preglottalized voiced stop. In this sound the initial glottal stop is clearly perceptible and the voiced stop following the glottal stop is fully voiced. In our analysis of Sui, our native speaker produced strong preglottalized stops like Li's type one. Although in the literature on the Sui language, the preglottalized stops have sometimes been reported to be slightly imploded in their onset. Our airflow studies show that the Sui preglottalized stops are normally not true implosives but are very much as Li first described them (Li 1943: 178-9). They are preceded by a moderate glottal stop, and the voiced consonant following this initial glottal stop is in modal voice. Anthony Traill (personal communication) reports that the initial preglottalized nasals [ʔm] and [ʔn] in !χóõ Bushman are preceded by a moderate glottal stop and the nasal and following vowel are not colored by any type of creaky phonation. In other words they are very much like Li's (1943) type one preglottalized stops.

The initial voiceless unaspirated oral stops and affricates of Sui [p t ts tɕ k q] are all made with a PREPHONATION state of the glottis (Harris 1999: 2042-3; 2001:4-5), cf. Figure 1. In the production of the prephonation state of the glottis, the ventricular folds are abducted and the arytenoid cartilages are adducted as for modal voice, but the true vocal folds are not completely closed. The vocal folds form a narrowed convex-convex opening medially in the glottis and there is insufficient subglottal air pressure during the closure phase of the articulatory stricture to initiate an airflow through the narrowed glottal opening. A very small airflow through the glottis is initiated during the release phase of the consonant and the overlapping onset phase of the following vowel when the subglottal air pressure increases and a small amount of air escapes through the narrowed glottis. This small amount of air is used to help initiate the first stage of the glottal cycles of voice and produces a predictable small amount of Voice Onset Time (VOT) lag before the full voicing cycles of the following vowel are reached.

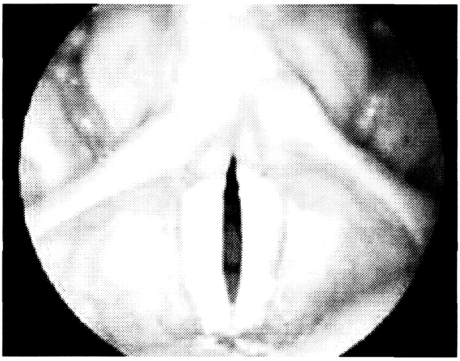

Figure 1. A cardinal prephonation state of the glottis (Esling and Harris 2002).

The syllable initial voiceless aspirated oral stops and affricates [ph th tsh tɕh kh qh], the voiceless fricatives [f s ɕ x h], and the voiceless nasals [m̥ n̥ ɲ̊ ŋ̊] are all made with a BREATH (VOICELESSNESS) state of the glottis, cf. Figure 2.[3] In the breathed /brɛθt/ state of the glottis the true vocal folds, the ventricular folds, and the arytenoid cartilages are all abducted but not to the extent of forced inhalation. The breathed state of the glottis is characterized by a slightly turbulent airflow through the wide open glottis. The degree of stress and aspiration can influence the width of the opening of the glottis and the width of the opening of arytenoid cartilages. The heavier the aspiration and the higher the stress, the wider open they are and the longer the VOT lag.

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[3]In all photographs the top of the picture corresponds to the back or posterior part of the larynx. Voiceless nasals in Sui begin with a breath state of the glottis and end with a voiced state of the glottis [m̥m].

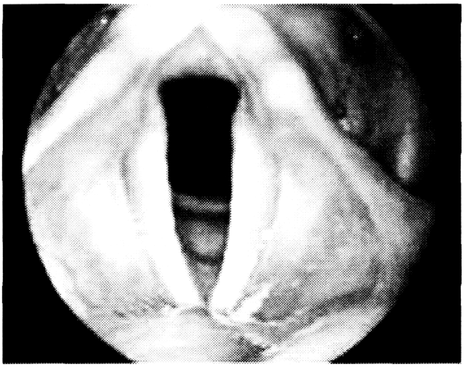

Figure 2. A cardinal breath (voicelessness) state of the glottis (Esling and Harris 2002).

The syllable final voiceless oral stops /-p -t -k/ represent final voiceless unreleased double articulations of glottal stop plus oral stop simultaneously [ʔ͡p ʔ͡t ʔ͡k][4]. The final voiceless unreleased double articulations [ʔ͡p ʔ͡t ʔ͡k] and the glottal stop [ʔ], including the glottal stops preceding preglottalized consonants [ʔb ʔd (ʔg) ʔj ʔw ʔɣ ʔm ʔn ʔɲ ʔŋ] all have a closed UNPHONATED state of the glottis (Catford 1990: 26). We now have direct visual evidence that the preglottalized consonants are preceded by moderate glottal stops, which will be discussed below. The voiced consonants following the initial glottal stops are normally in modal voice. We have never recorded instances of preglottalized consonants following glottal stop in creaky voice.

In the literature, glottal stop is usually defined simply as a closed or tightly closed glottis, which are neither precise nor complete definitions of glottal stop. The production of glottal stops includes complete adducted vocal folds, partially adducted ventricular folds helping to reinforce the glottal closure, and slight constriction of the whole laryngeal vestibule. The laryngeal vestibule, according to Zemlin (1988), is defined as the supraglottal cavity that extends from the ventricular folds upward through the aditus laryngis. It is formed anteriorly by the epiglottis, posteriorly by the apexes of the arytenoid cartilages, and laterally by the aryepiglottic folds. The sphincter mechanism constriction of the supraglottal cavity is on a continuum beginning with a moderate glottal stop described above and can increase until the aryepiglottic sphincter mechanism can form a complete closure as in the production of an epiglottal stop. Although the sphinctering mechanism of a moderate glottal stop is slight when compared to an epiglottal stop, it should not be ignored. It is part of the basic production components of a glottal stop in Tai and Kam-Sui languages. See Figure 14 below.

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[4]Calling these sounds *double articulations* means that we are following the rank order of strictures of J. C. Catford 1977. If we choose to follow K. L. Pike 1943, these sounds would be described as *glottalized* stops, since Pike treated all glottal stops as a lower rank order of stricture than oral stops.

4. Tone plots

The tone plots presented here are based on data taken from one of the authors, James Wei, a native speaker of Sui from the village of Miaocao about seven km from Shuilong, one of the locations in SDB 1956. Mr. Wei produced multiple tokens of actual Sui vocabulary items as indicated below. The recordings were made in Beijing, China at the Central University of Nationalities with high quality audiotape using a Sony TCM-5000 professional quality cassette tape recorder and a ATR 20a Audio Technica dynamic, uni-directional microphone. Each test item was repeated three or more times and from these multiple tokens the pitch trajectories were extracted using WinCecil Speech Analysis software (SIL International). In order to eliminated artifactual differences from the multiple repetitions of a given lexical item, each set of pitch trajectories was normed for length and for pitch height and then a mean value for each 5 msec point across the course of the syllable was computed. The software performing these operations was developed by Jerold A. Edmondson. Once the mean trajectories had been established, the files were transferred to ®MS-Excel for plotting. The resulting plots are given below in Figures 3 through 6. Note that some of the phonetic values of the tones are slightly different from the values expected from Li 1948 and from the values given in SDB 1956.

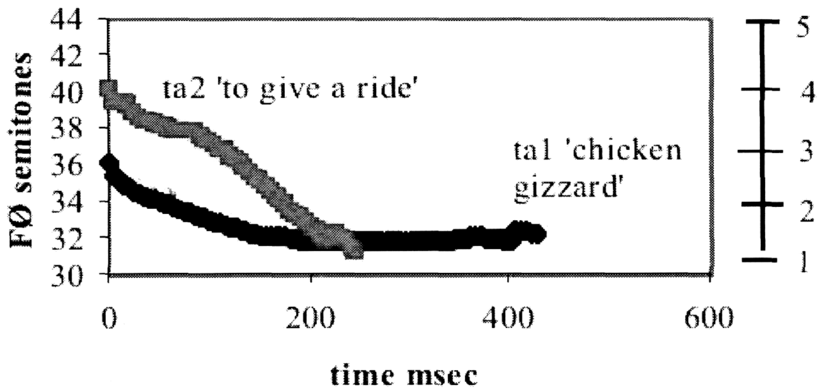

Figure 3. Sui Tones 1 and 2

For Tone 1 we expected a 11 or a 13 trajectory from previous work. The actual value determined from our experimental procedure fell from an onset of 36 st to a value of 32 st, corresponding approximately to a 31 on Y. R. Chao's Scale of Five, whereby the track was mostly level after 200 msec. Tone 2 was expected to show a 31 "low falling" trajectory, but began at about 40 st and fell linearly to 32 st reaching this value at a point a little beyond 200 msec. We would assign it a value of 41.

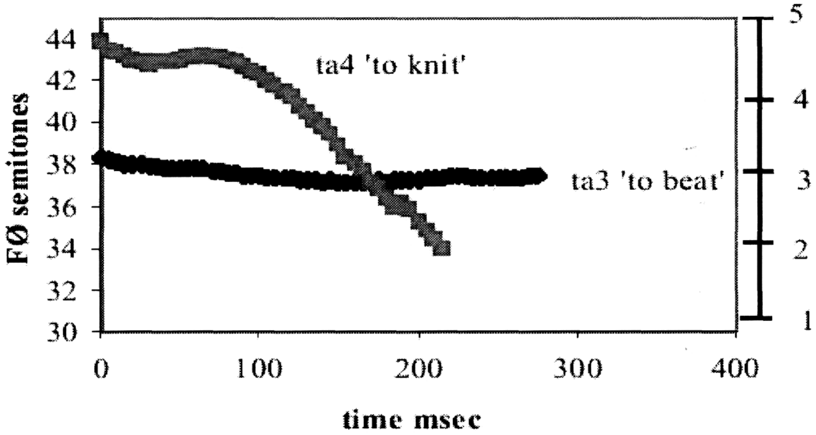

Figure 4. Sui Tones 3 and 4

For Tone 3 in Figure 4 a value of 33 was expected and our data showed a pitch track at 38 st that was more-or-less level across its entire course. Tone 4 was supposed to begin with a high pitch and fall to middle, i.e. 53. We found a shape with a slight rise and then fall from 44 st to approximately 33 st, or a 42 pitch trajectory.

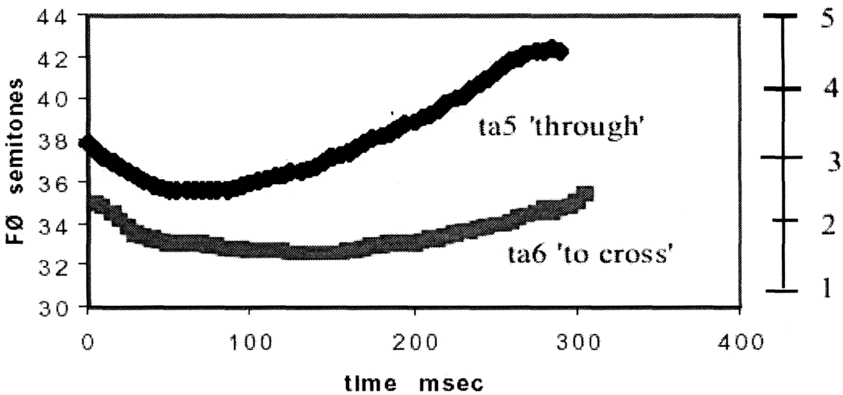

Figure 5. Sui Tones 5 and 6

Tone 5 in Figure 5 was described as high rising beginning with a mid pitch and rising to high. We found it to have a slight dip to 36 st after onset at 38 st with a following rise to 43 st. We would assign it a value of 35 despite the dip to 2 at onset. Tone 6 deserves careful attention. Li records it as high level or a 55. This result is quite unlike the pitch trajectory we determined, which begins at 35 st, dips to 32 st, and then rises to 36 st. The Tone 6 depicted here is similar to the 24 tone value used in some places for native Sui vocabulary for this tone and is not the 55 value (high level) used for Chinese loanwords that is found in some places for Tone 6. SDB (1956) reports that some locations have two values for Tone 6, i.e. Zhonghe, Hengfeng, Shuilong, and Yang'an. It is to be noted that James Wei's village, Miaocao, is, in fact, quite close to Shuilong. Moreover, *ta*[6] is a native Sui word, which is cognate in the Kam language, *ta*[6] 'to cross' and contrasts with the Han word *kuo*[24] 'to cross'.

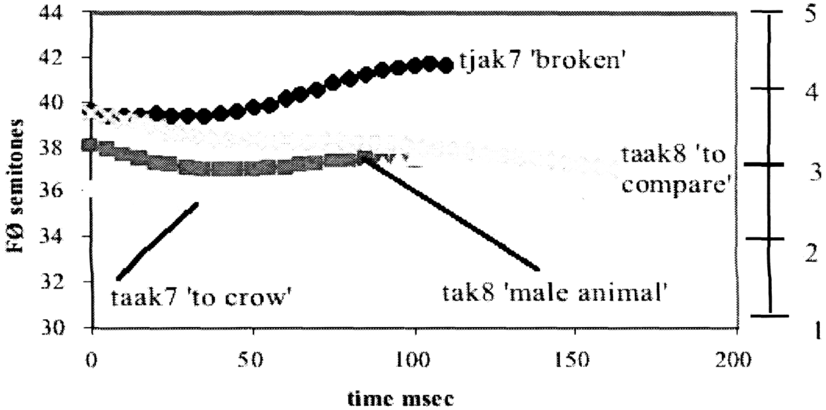

Figure 6. Sui Tones 7S, 8S, 7L, and 8L

In Figure 6 we plot the pitch trajectories of four lexical items realized in closed syllables. In Kam-Tai studies these tone categories are called 7S, 7L, 8S, and 8L, whereby 7S and 8S had short vowels and 7L and 8L had long vowels. The expected pitch trajectories was: for Tone 7S a 5(5) shape, Tone 8S a 43, 32, 43, and 21 shapes, Tone 7L a 35 shape, and Tone 8L showed quite diverse values, 42, 31, 33, and 32. We found that 7S began at about 40 st and rose slightly to 42 st, for which we would assign a value of, perhaps, 44. The Tone 8S starts at 38 st and falls very slightly to 37 st across it course, a value of 43. The Tone 7L start at 36 st, dips slightly, and then rises to 40 st or a value of 34. Tone 8L starts at 40 st and falls to 38 st, or a value of 43. Note carefully that the long and short vowels of Tones 7 and 8 are clearly in evidence in these plots. Moreover, the tone values for Tones 7 and 8 seem to differ the most from those expected from previous work, presumably because they are much shorter in duration and allow less time to decide about pitch height. Even in SDB 1956 the variation of values was most pronounced in Tones 8S and 8L.

5. Airflow charts and discussion

It was mentioned at the beginning of this paper that the Sui language possesses many features that have been simplified in related languages, such as Thai, Lao, Shan, and Kam, e.g. *four series of labial and dental stop initials:* unaspirated, aspirated, voiced, and preglottalized /p ph t th b d ʔb ʔd/ as well as a series of preglottalized nasals /ʔm ʔn ʔɲ ʔŋ/. Of all of these, the preglottalized stop series has been phonetically the one that has stimulated the greatest amount of discussion because of its widespread occurrence throughout the family and the lack of clarity about the phonetic gestures involved in its production. The preglottalized series in Tai and Kam-Sui languages was first posited, as far as we know, by Li Fang Kuei (1943), possibly because he was introduced to these initial voiced preglottalized sounds in Northwest Native American languages by his teacher Edward Sapir, while he was a graduate student at the University of Chicago. As stated earlier, the 1943 description of Li's first type of preglottalized voiced stop was the norm for our Sui native speaker's production of the preglottalized [ʔb] and [ʔd]. The voiced consonants are preceded by a moderate glottal stop and the following voiced consonant is in modal voice not a type of creaky voice. In the following section we will provide direct visual laryngoscopic evidence of the gestures involved in the production of glottal stop and preglottalized voiced stop, nasals, fricatives, and approximants.

In order to study the airflow features of Sui preglottalization, James Wei produced a number of tokens of utterances with preglottalized voiced stops into the Rothenberg Mask. The Rothenberg Mask (Glottal Enterprises, Inc.) is a circumferentially vented hard plastic mask for low distortion measurement of oral and nasal airflow, cf. Rothenberg (1977). It possesses two chambers with an air pressure transducer in each that converts the dynamically changing air pressure into an electrical signal. In this study we connected the output of the oral airflow transducer to a small battery operated amplifier of our own construction to boost the signal to line level. The output of the amplifier, in turn, was interfaced to a Cecil Box (SIL International, Inc.) and laptop computer running the Cecil software for capturing the signal in volatile memory. Because the Cecil Box was a mono-channel device with no multiplexing capacity, only the oral waveform was captured. These waveforms are displayed on a time scale showing their relative duration, cf. Figure 7 duration of about 400 msec.

As we also noted above, many investigators have suggested that the preglottalized stops and possibly other preglottalized consonant initials might be formed with imploded airstream, we have compared in Figure 7 and Figure 8 the airflow properties of the Sui preglottalized initial /ʔd-/ in the syllables /ʔda^{1}/ 'to build, erect' with the airflow properties of an imploded *b*- initial in the syllable [ɓɐi^{44}] 'villages' in a language possessing truly imploded airstream, Dinka of Bor, Sudan, a Nilotic language (speaker Margaret Kuol).

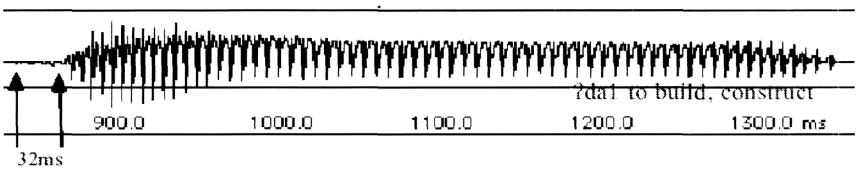

Figure 7. Airflow recording of /ʔda[1]/ 'to build, construct'

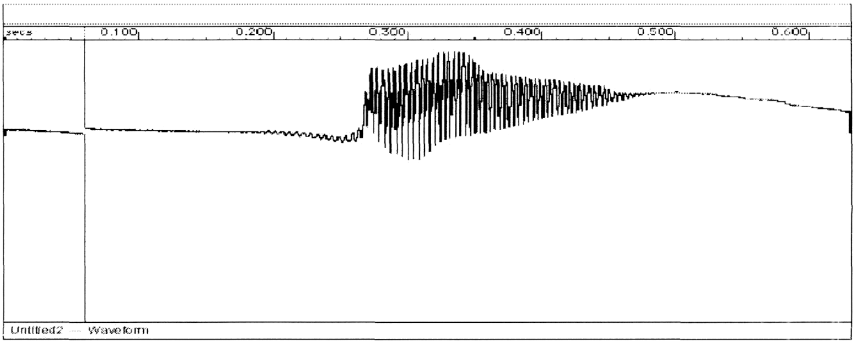

Figure 8. Bor Dinka of Sudan *ɓɒi*[44] 'villages'

As can be seen in Figure 7, there is no pronounced ingressive or imploded pulse at the onset of *ʔda*[1]. By contrast Figure 8 shows an airflow value with voicing during the consonant initial in *ɓɒi*[44] that tends downward becoming more negative over its course and jumps abruptly to a much higher level upon release.

6. Laryngoscopic research and discussion

Figures 7 and 8 above have suggested that Sui preglottalized initial stops and true imploded initials of Dinka might be produced differently. The following section reports on our direct layryngoscopic observation of Sui consonants with preglottalization The method used here involves a fiberoptic scope first developed by Sawashima and Hirose (1968), using a fiberoptic tube to observe and measure the vocal folds and other supraglottal activities such as the arytenoid cartilages, the ventricular folds, the epiglottis, the aryepiglottic folds, and the supraglottal laryngeal sphinctering mechanism.

For our research experiments we employed the Kay Elemetrics Rhino-Laryngeal Stroboscope 9100 with a fixed halogen light source, an Olympus ENF-P3 flexible fiberoptic laryngoscope, coupled to a Sony DCR-TRV17 Mini-DV Digital Camcorder for recording. A narrow fiberoptic bundle was inserted through the nose and positioned over the glottis just above the level of the apex of the epiglottis. James Wei then produced several tokens of the test vocabulary set that was selected to illustrate preglottalized nasals and voiced stops. These were recorded and later compared to laryngoscopic observation of plain nasals and (prenasalized) voiced stops.

In order to better define structures for reference below, consider Figure 9 with James Wei's glottal structures in the breath position with arytenoids, vocal folds, ventricular folds, and aryepiglottic folds clearly in abducted positions.

In Figure 10 below we present sequences of stills from the video recordings sometimes separated by one or two frames (30 frames/sec recording speed).

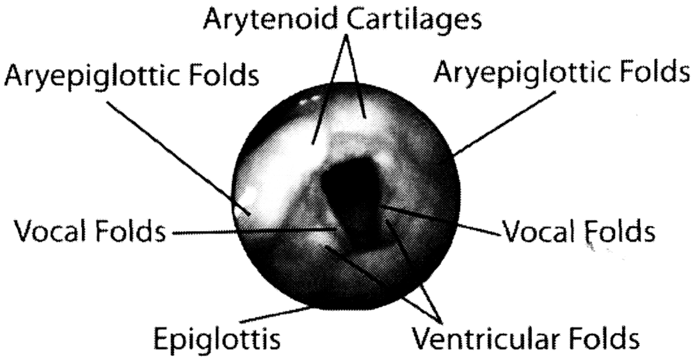

Figure 9: Glottal structures illustrated in a wide-open breath position.

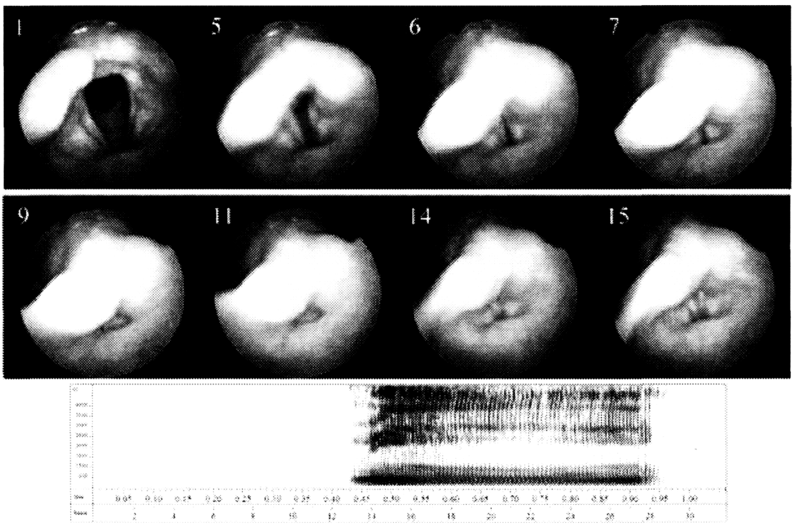

Figure 10. Sequence of stages in the articulation of *ʔmi*[1] 'bear', including laryngoscopic images and a spectrogram. Photographic frames are indicated at "the" bottom of the spectrograms.

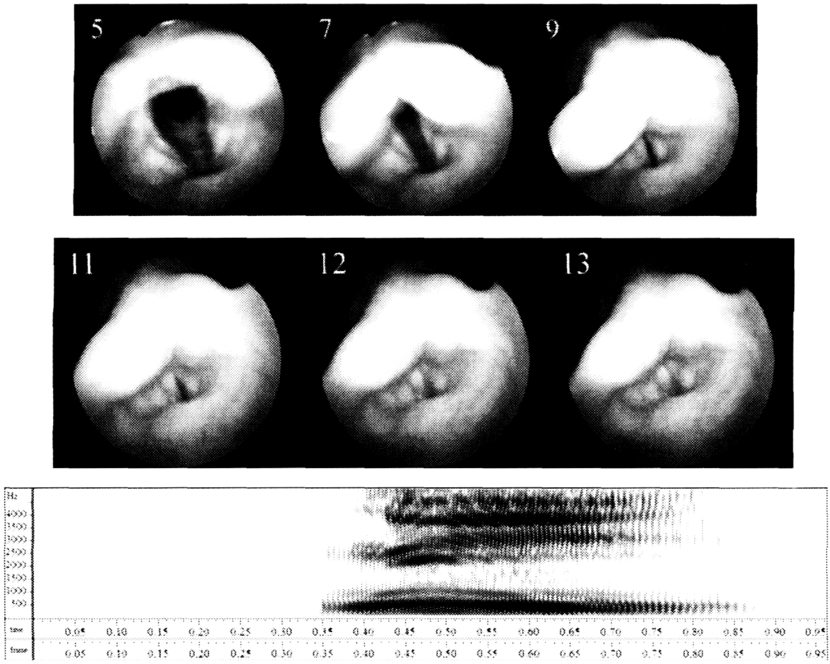

Figure 11. Sequence of stages in the articulation of *ni*[4] 'mother'

Before articulation of *ʔmi*[1] 'bear' begins (frame 1), the glottis assumes the state of the glottis for breath. At onset of activity, the vocal folds start to approximate in an adductory maneuver as the aryepiglottic folds begin to sphincter anteriorly (frame 5). Before the vocal folds are completely adducted, the ventricular folds are already beginning to close over the vocal folds (frames 6-7). In frames 9-11, the ventricular folds are approximated, nearly hiding the vocal folds beneath, and the angles of the aryepiglottic folds compact anteriorly so that the aperture is sphinctered nearly completely shut. Then the sphincter begins to open, causing the ventricular folds to part and expose the vocal folds (frame 14), which phonate in modal voice in frame 15.

In Figure 11, we provide a contrast to Figure 10 of an item without a preglottalized initial, *ni*[4] 'mother'. The most significant difference between the two figures is the absence of sphinctered glottal closure. From the position of breathing (frame 5), the glottis begins to adduct until the vocal folds are in a position to phonate (frame 11). There is no inward movement of the ventricular folds or anterior buckling of the aryepiglottic folds as was evident in frames 7-11 of Figure 10. In Figure 11, the characteristic features of a moderate glottal stop--the adduction of the vocal folds, the compression of the ventricular folds over the glottal space, and the sphinctering of the aryepiglottic mechanism--are very much in evidence, after which the sphincter reverts to open position and the ventricular folds uncover the vocal folds, which remain adducted and phonating.

We also examined recordings of vocabulary with *ʔb* and *ʔd* initials. The resulting laryngoscopic slides are presented in Figure 12 and Figure 13. Some examples in our preglottalized data set showed the pitch shape of Tone 5, cf. Figure 5 above. This tone shape caused James Wei to form the glottal stop while the larynx was raised and therefore out of view of the laryngoscope. He then lowered the larynx while maintaining *ʔ* closure. The recordings of stages in the production of *ʔdi*^{5} 'borrow money' yield similar obscuring of the glottal area while raised, cf. Figure 14. We believe that these larynx height changes are caused by the falling-rising pitch trajectory of Tone 5. Nevertheless, the first three frames of Figure 13 show unmistakably the presence of glottal closure with considerable aryepiglottic sphinctering and ventricular compaction. Thus, it appears certain that the mechanisms seen in preglottalized nasals are also active in preglottalized voiced stops. Based on Figures 10, 12 and 13, we conclude that the glottal stop of Sui is stronger than the moderate glottal stop we have viewed in other languages. But it is not an epiglottal stop, cf. Figure 14.

In Figure 15 we present one final piece of evidence that preglottalization in Sui is phonetically a moderate glottal stop followed by a voiced stop, a voiced nasal, a voiced approximant, or a voice fricative. As Li's early work showed, preglottalized consonants pattern in their tonal development identically to syllables that start with glottal stops. It would, thus, be of interest to compare the plain moderate glottal stop followed by a vowel with Figures 10, 12 and 13, i.e. glottal stop nasal or by voiced oral stop with glottal stop followed by a vowel. Consider the sequence of moderate glottal stop slides taken from the videotape for *ʔi*^{1} 'frog'.

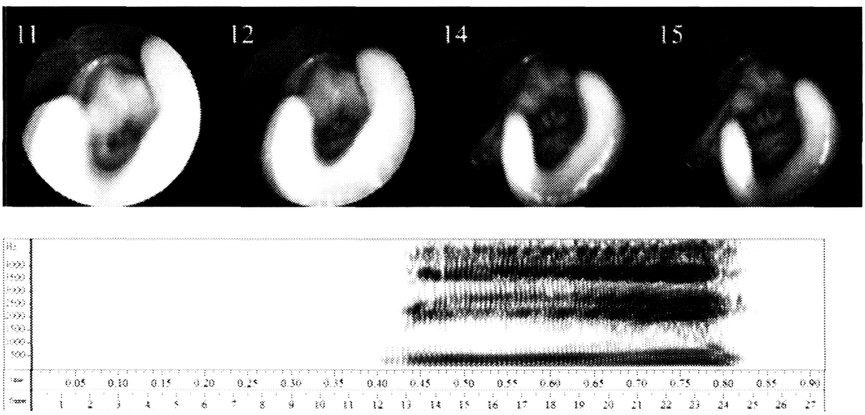

Figure 12. Sequence of stages in the articulation of *ʔbi*^{5} 'dipper'

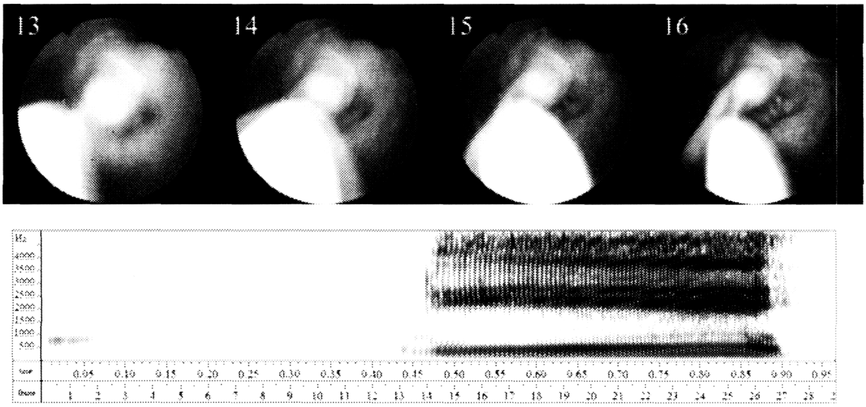

Figure 13. Sequence of stages in the articulation of *ʔdi*^{5} 'borrow money'

In such a syllable with a moderate glottal stop followed by a vowel one sees the same sequence of glottal gestures as was observed above: glottal stop in frames 6-8 opening to voicing in frame 9. We conclude that the moderate glottal stop before the vowel in Figure 15 is identical to the glottal stop before the nasal in Figure 10 and before the voiced oral stop in Figure 12 and 13[5].

The laryngoscopic evidence supports the claims that this class of preglottalized initials is formed from a sequence of moderate glottal stop released into a voiced nasal, a voiced fricative, a voiced stop or voiced approximant including vowels, similar to their description by Li Fang Kuei (1943). In our research there is no evidence, including larynx lowering and airflow evidence, of pronounced implosion in the production of the preglottalized stops. The glottal valve does move downward a bit during the stricture phase of the stops, but the downward movement is neither rapid nor large. It appears that contrary to what one might think the initial sequence of glottal stop plus voiced oral stop and the final sequence of voiced oral stop plus glottal stop are both phonetically possible without implosion occurring. In general larynx height changes are primarily associated with tonal pitch changes.

Catford (1977:73-7) states that larynx lowering in glottalic suction voiced implosives is greater and faster than for pulmonic pressure voiced plosives. Also the rate of pharyngeal expansion is greater and faster in glottalic suction voiced implosives than in pulmonic pressure voiced plosives. In fact, a comparison of the downward movement of the glottis in *ʔmi*^{1} 'bear' vs. *ni* 'mother' using *Wavesurver* with the video plugin showed durations of 13 msec vs. 16 msec with the depression of the larynx in the latter example extending

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[5]We also would note that for these examples cessation of voice does not involve glottal stop but simple abduction of glottal folds.

well into the voiced part of the syllable. In the case of *ʔmi*[1] 'bear' the depression was completed before the onset of voicing. Neither seemed to correspond to "Catford's description of a glottalic suction voiced implosives," requiring the larynx to move downward over a static column of air with attendent absence of pulmonic initiator activity. Although glottalic suction voiced implosives may occur in other varieties of Sui not observed, they do not occur in the speech of James Wei.

7. Conclusions

This research has confirmed much previous work by Li Fang Kuei (1948, 1977b) and others such as Zhang (1980) and Zeng and Yao (1996) on the phonological analysis and phonological structures of the Sui language. One of our major objectives was to determine if Li's analysis that preglottalized consonants are actually preceded by glottal stops was correct. We obtained direct visual evidence that glottal stops do precede preglottalized consonants and also vowels and that there is no laryngealization of the following vowel. We also have direct instrumental evidence that shows little or no implosion of preglottalized consonants in Sui.

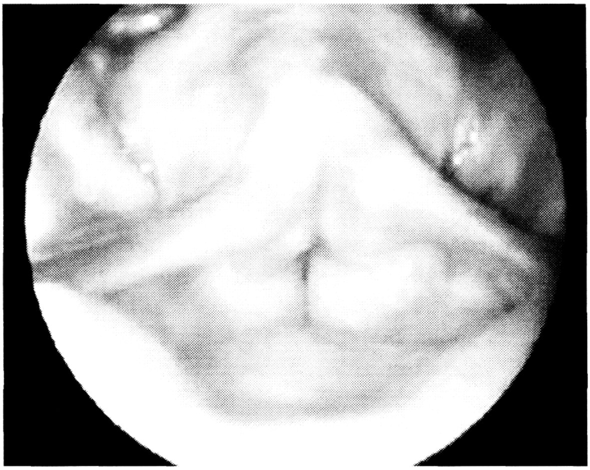

Figure 14. A cardinal glottal stop state of the glottis (Esling and Harris 2002).

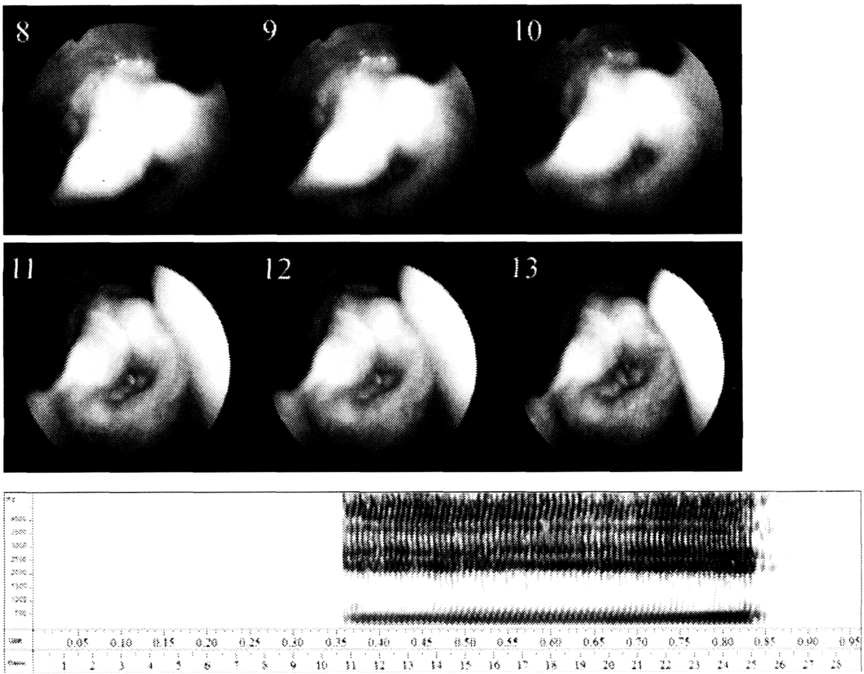

Figure 15. Sequence of states in the articulation of /*ʔi*^{1}/ ‘frog’

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Department of Linguistics and TESOL
University of Texas at Arlington
USA
<j.edmondson@sbcglobal.net>