

Pitch as a Physical Correlate of Stress in Gedeo Nouns

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Abstract: This study aims at investigating the acoustic correlates of stress in the nouns of the Gedeo language. Acoustic analysis is employed to analyze 81 nouns recorded from three native speakers of the languages. Results showed that, in this language, pitch variations are significant correlates of stress in nouns. Unlike the general literature on the phonetic correlates of stress, duration, particularly vowel length, does not appear to be a consistent correlate of stress.

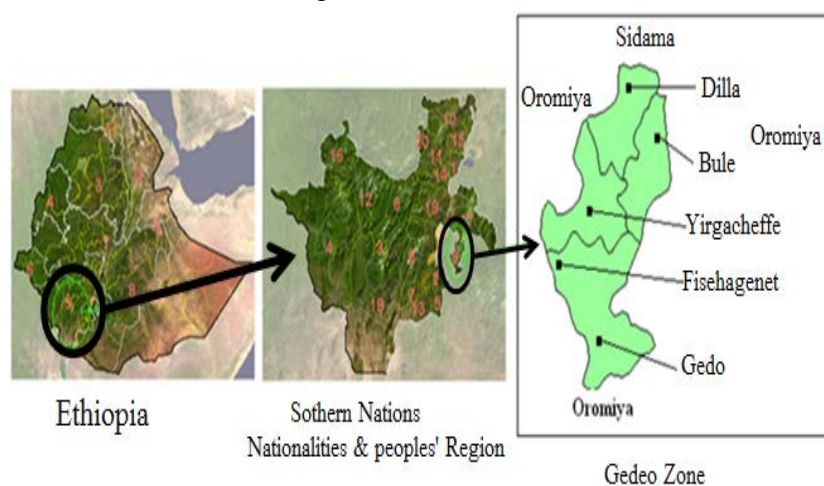
Introduction

Gedeo (Gede'uffa, as referred to by the native speakers) is a Highland East Cushitic language of Ethiopia spoken as first language by 1,474,912 persons (Central Statistical Agency of Ethiopia 2007). The Gedeo inhabit the Southern Nations, Nationalities and Peoples' Region (SNNPR, see Map 1). They are surrounded by the Sidaama zone in the north and Oromiya region in the south, east and west. The Gedeo people, like other neighboring ethnic groups, essentially base their living on agriculture. Enset is their staple food. They are also widely known for their coffee.

The present paper compares vowel duration word medially and finally to see whether duration is correlated to stress. It also attempts to examine whether pitch and/or intensity have any interconnection with stress. For this purpose, 81 nouns were recorded from three adult informants, all male. Only male subjects were considered in the current study as the status of stress in Gedeo has already been

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established, which was done by taking gender-related variations into account (e.g., Wedekind 1980; Leulseged 1981)).



Map 1: Gedeo Zone Administrative Map (Adopted from (Map Library 2009))

The data was recorded using a Sennheiser® Microphone and Kay Elemetric® CSL 4400 system attached to a computer, sampled at 16-bit and 44.1 kHz. The recordings were done at the Phonetic Laboratory of the Department of Linguistics, Addis Ababa University. Basically, two software packages, i.e., Praat (Boersma and Weenink 2010) and Speech Analyzer (SIL International 2006), along with some statistical techniques, were employed for the analysis of the data. Spectrograms were used to determine segment boundaries and measure vowel duration, pitch, and intensity of the recorded nouns.

Previous works

In 1937, pioneer work on Gedeo was conducted by the Italian linguist Martino Mario Moreno. Later Klaus Wedekind provided extensive linguistic descriptions of the language. According to Wedekind (1990:17), research by Ethiopians on Gedeo

and Sidamo started in 1977 with the extension of research at the Addis Ababa University and the Academy of Languages, which, up to that time, was confined to the study of Amharic and Ge'ez. Since then, quite a lot of work has been carried out. Wedekind (1980) discusses phonetic and phonological aspects of Gedeo and other closely related adjacent Highland East Cushitic languages, namely Sidaama and Burji. This work recognizes the existence of linguistic stress in Gedeo and other neighbouring Highland East Cushitic languages and highlights the importance of describing stress not just from the point of view of phonology, but with considerations of semantic and textual perspectives as well.

Leulseged (1981) provides a contrastive analysis of the phonology of Gedeo and Amharic. According to Eyob (2006), both Wedekind (1980) and Leulseged (1981), concur on the fact that, in Gedeo, the final syllable of the word stem is stressed without discussing the acoustic properties correlated with stress. Thus, this article examines whether the final syllable of a noun is stressed and if so, what physical properties are correlated with stress in Gedeo nouns. Before doing so, it is of interest to discuss the nature of stress and some of the physical correlates of stress. Ladefoged (2005:250) considers the amount of air pushed out of the lungs as well as the resulting pitch increase as the two physical correlates of stress. He notes:

Stressed sounds are those on which the speaker expends more muscular energy. Usually this involves simply pushing out more air from the lungs by extra contraction of the muscles of the rib cage. ... [W]hen there is an increase in the amount of air being pushed out of the lungs, there is an increase in the loudness of the sound produced. ... [A] much more important indication of stress is the rise in pitch that occurs when there is an increase in the flow of air out of the lungs.

Fry (1955:768), on the other hand, claims that “[D]uration and intensity ratios [in English] are both cues for judgments of stress and that...duration ratios is a more effective cue than intensity ratio.” (Fry's (1955, 1958, 1964) pioneering studies on

English stress and subsequent research on other languages over the last fifty years (e.g., Dogil and Williams 1999 for German; Kastrikani 2003 for Greek; Ortega-Llebaria 2006 for Spanish; Manolescu, Olson, and Ortega-Llebaria 2009 for Romanian) have indicated that duration is cross-linguistic and a correlate of stress. But, as indicated by Fry (1955), it appears that a certain acoustic property significantly correlated with stress in one language may - or may not - be relevant in a different language. Hence, the question of the present study is, which acoustic features are most closely correlated with stress in Gedeo. The study will focus on a list of nouns (cf. appendix), recorded as one-word-utterances.

Vowel duration in Gedeo

Since the present data does not allow for a distinction of (a) length conditioned by utterance final position and (b) length conditioned by stress, further studies will have to address that distinction. The focus here is on stress in relation to vowel quality, pitch and loudness. Gedeo has five vowels /i/, /ɛ/, /a/, /ɔ/ and /u/, all of which can be phonemically short and long in word medial position. All vowels in word final position are phonemically short. In Gedeo nouns, the vowel /u/ does not appear word finally. The following two tables present the consonant and vowel phonemes of Gedeo.

Table 1: Consonant Phonemes of Gedeo. Adapted from Wedekind (1980).

	Bilabial	Labio-dental	Dental	Alveolar	Palato-Alveolar	Palatal	Velar	Glotal
<i>Plosives</i>	b		t d				k g ʔ	
<i>Ejective</i>	p'		t'		tʃ'		k'	
<i>Implosive</i>					d̥			
<i>Fricatives</i>		f	s		ʃ			h
<i>Affricates</i>					tʃ dʒ			
<i>Nasal</i>		m			n		ŋ	
<i>Lateral Approximants</i>					l			
<i>Trill</i>					r			
<i>Approximants (Glides)</i>		w					j	

Table 2: Vowel Phonemes of Gedeo. Adapted from Wedekind (1980).

	Short Vowels			Long Vowels		
	Front	Central	Back	Front	Central	Back
High	ɪ		ɔ	ii		ɔɔ
Mid	ɛ		u	ɛɛ		uu
Low		ʌ			aa	

Before going into the analysis of duration of vowels in relation to stress and utterance final position, it is of interest to distinguish the average duration of each of the short and long vowels. Table 3 shows the mean duration of each vowel, and the ratio of long vowels versus their respective short counterparts. The average duration of each vowel assumes fifteen instances, five from each informant. All measurements were conducted on medial vowels.

Table 3: Word Medial Position: Average time (in sec.) of short and long vowels and ratio of long vowels in relation to their short counterparts.

Vowels	MDSV (in sec.)	MDLV (in sec.)	Ratio long/short (in sec.)
i	0.067829	0.135224	1.994
ε	0.081283	0.171766	2.114
a	0.078081	0.188517	2.415
ɔ	0.090005	0.177398	1.971
u	0.064665	0.165557	2.561
Mean	0.0763726	0.1676924	2.211
Variance	0.00011	0.00041	0.06956

As can be seen from the ‘ratio’ column of Table 3, the word medial long /i/ and /ɔ/ are approximately twice as long as their short counterparts. The word medial long /ε:/, /a:/ and /u:/ are even more than twice as long. For a better view of the time differences among the long and short vowels see Fig. 1.

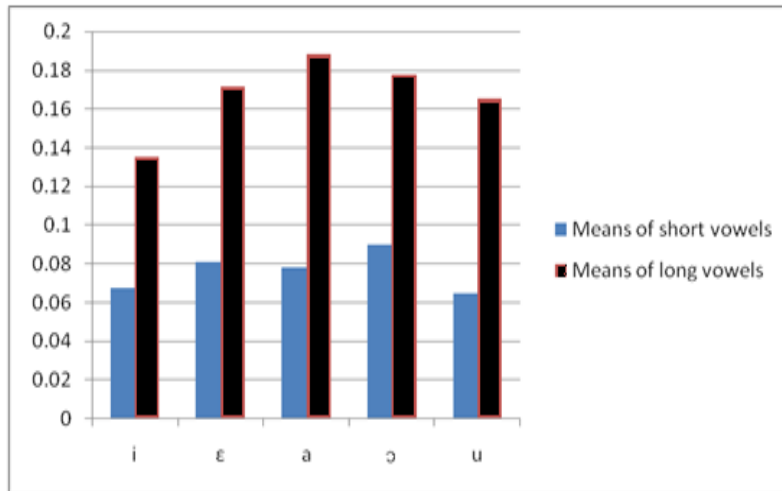


Fig. 1: Word Medial Position: Means of time (in sec.) of short and long vowels and ratio of long vowels in relation to their short counterparts.

It appears that the ratios for /a/ and /u/ are considerably bigger than the rest; while /i:/ and /o:/ and their short counterparts have smaller ratios compared to the other vowels. Both short and long /i/ have the shortest duration, and hence the ratio is also the smallest. /o/ has a small ratio because the short /o/ is the longest of all short vowels.

Significant differences among the ratios are found only for /i/. The variance of the short vowels (i.e., 0.00011) shows that the short vowels have similar duration. The variance of the long vowels (i.e., 0.00041), however, signals that there is one value which is distant from the mean, namely the value for the long /i/.

Vowel length versus stress in Gedeo nouns

Table 4 and Fig. 2 show the mean duration of four word final vowels, so that mean duration of final vowels can be compared with the average duration of word medial

short and long vowels. In Gedeo nouns, the vowel /u/ does not appear word finally, and therefore the analysis does not consider it.

Table 4: Mean duration of the four Gedeo vowels occurring word finally

i	ɛ	a	ɔ
0.115	0.114	0.429	0.434

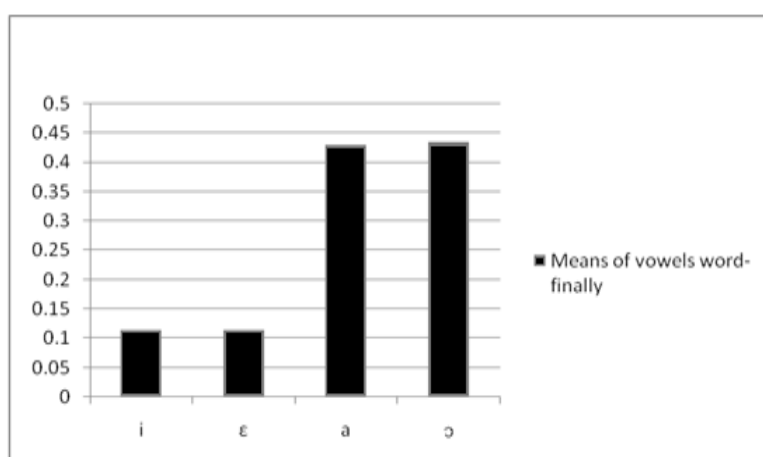


Fig. 2: Mean duration of the four Gedeo vowels occurring word finally.

It can be observed from Table 4 and Fig. 2 that /a/ and /ɔ/ are noticeably longer than /i/ and /ɛ/. In fact the vowels /a/ and /ɔ/ are identified as the longest vowels in word medial position. It should be noted again that no phonemic length is identified for word final vowels. All vowels are long, and even longer than their counterparts in medial position, because they occur in final position in citation form; otherwise, they are characteristically short. Having this in mind, compare the duration of the vowels word finally with the vowels already distinguished as long word medially to see the extent to which word final vowels are longer than long vowels word medially.

Table 5 and Fig. 3 show the degrees to which the four word final vowels are longer than long vowels word medially.

Table 5: Ratios of mean duration (ms) of the vowels word finally to mean duration of long vowels.

	i	ɛ	a	ɔ
MDVWF	0.11516	0.114321	0.429423	0.43489
MDLV	0.135224	0.171766	0.188517	0.177398
Ratio	0.852	0.666	2.278	2.452

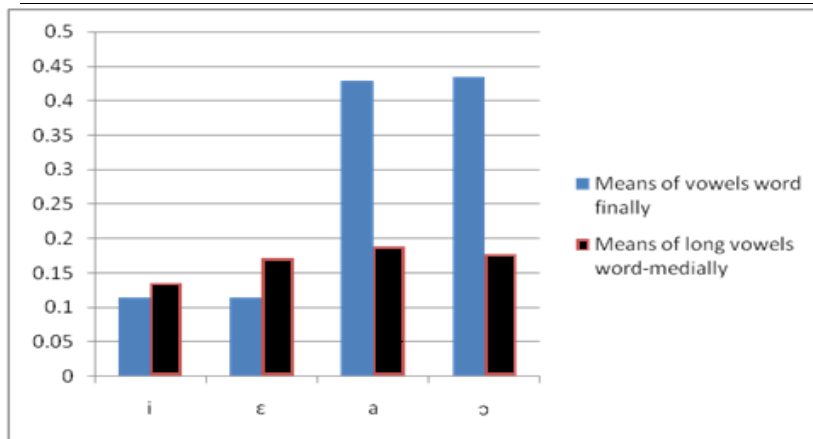


Fig. 3: Means of long vowels and mean of duration of the vowels word finally.

As already mentioned, word final /a/ and /ɔ/ are more than twice as long as the word medial long vowels, whereas word final /i/ and /ɛ/ are shorter than word medial /i:/ and /ɛ:/, respectively. Given the limitation of the present data, vowel length cannot be considered a marker of stress in Gedeo nouns; partly because /i/ and /ɛ/ are shorter in word final position than the long vowels of the language (i.e., /i:/, /ɛ:/, /a:/, /ɔ:/, and /u:/). Even for /a/ and /ɔ/, the word final length is not characteristic of them. This was tested by adding the possessive suffix {-tt'a} to nouns ending with /a/ and /ɔ/, and measuring the duration. Therefore, it must be other acoustic features - such

as pitch or intensity, which mark stress. In what follows, pitch and intensity will be discussed in relation to stress.

Pitch and intensity versus stress

Ladefoged (2001:93) suggests, that “... a stressed syllable is often, but not always, louder than an unstressed syllable. It is usually, but not always, on a higher pitch. The most reliable thing for a listener to detect is that a stressed syllable frequently has a longer vowel than that same vowel would be if it were unstressed.”

For the present list of Gedeo nouns, vowel length cannot be considered a determining feature of stress. A different physical correlate needs to be identified. Since the problem of vowel length as a correlate of stress is observed most clearly with /i/ and /ɛ/, intensity can be suspected to be a most reliable indicator of stress in nouns ending with /i/ and /ɛ/. Examine the following pitch plots and intensity graphs of two disyllabic and two trisyllabic nouns, namely /ʔisi/ ‘he, it’, /pɔlisitʃ:i/ ‘police-(wo)man’, /hak’:ɛ/ ‘five’ and /mɛla:l:ɛ/ ‘women’.

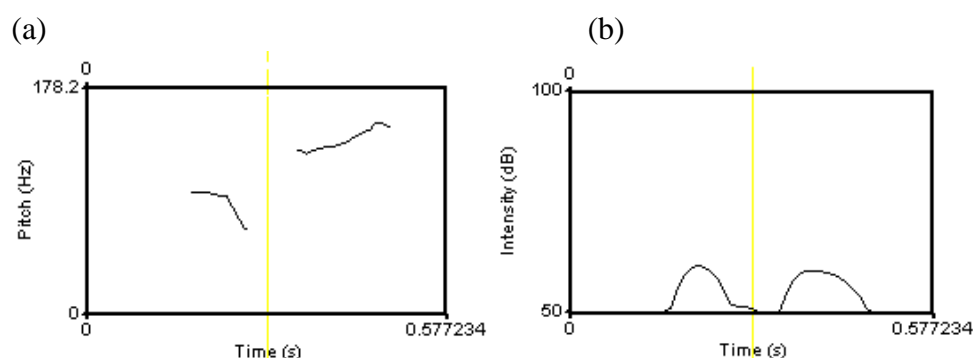


Fig. 4: Pitch plot (a) and intensity graph (b) of /ʔisi/.

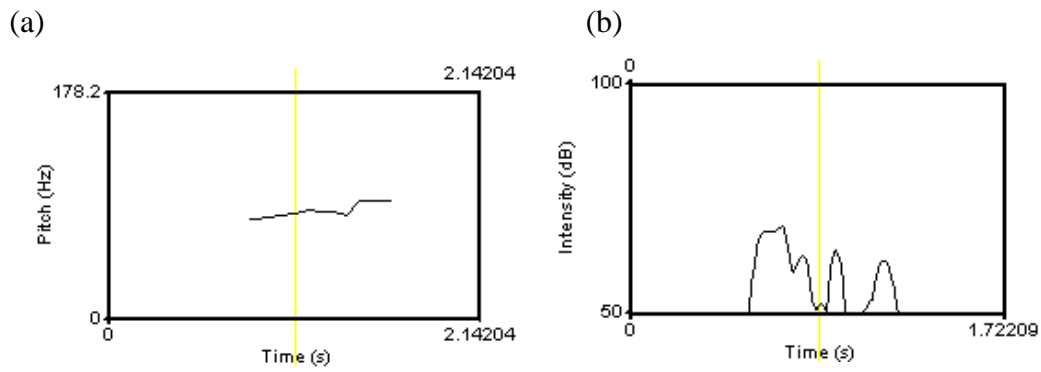


Fig. 5: Pitch plot (a) and intensity graph (b) of /pəlisitʃi/.

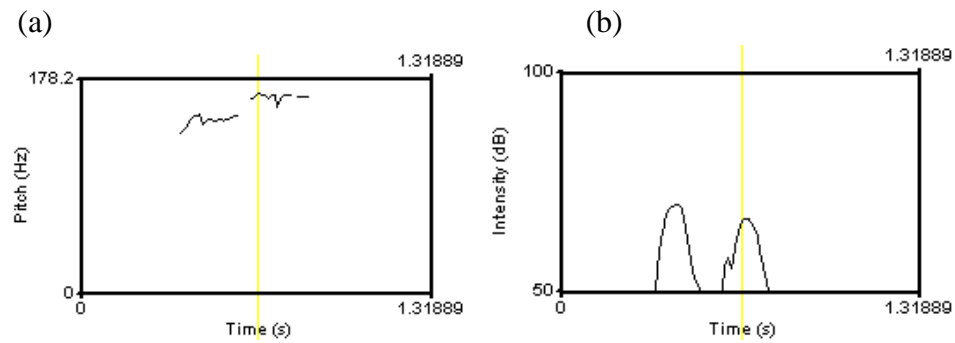


Fig. 6: Pitch plot (a) and intensity graph (b) of /hak'ɛ/.

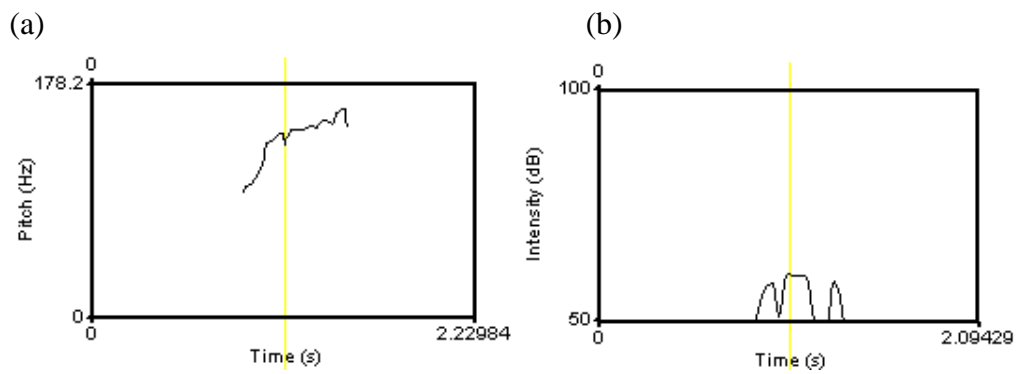


Fig. 7: Pitch plot (a) and intensity graph (b) of /mɛla:lɛ/.

In all four words the last syllable is high pitched. But the intensity of the last syllable is always lower than the other syllables. However, instances were also found where the final syllable is louder than the other syllables and yet no consistency of that pattern is observed. Therefore, pitch is found to be the consistent physical correlate of stress.

There is no strong correlation between intensity and stress, because it is not consistently attested in the majority of the nouns. Thus, Ladefoged (2005) claim is correct for Gedeo nouns: pitch is a more important acoustic property than length or intensity.

Unlike in English, where, according to Fry (1955) intensity is a determining physical feature of stress, in Gedeo intensity cannot be considered a determining physical property of stress. In some publications, there has been a tendency of defining stress simply in terms of loudness, but this is not a very useful definition if loudness is considered to be simply a matter of the amount of acoustic energy involved Ladefoged (1975:223). Brosnahan and Malmberg (1970:155-156) also strengthen Ladefoged's assertion:

Stress ... is a more complex phenomenon; recent work has shown clearly that stressed syllables are not differentiated from unstressed ones solely by physical intensity. Other features are always involved: thus, other things being equal, a longer syllable tends to be heard as stressed in comparison with a shorter syllable, a syllable with a higher pitch likewise, in comparison with one with lower pitch.

Conclusion

In Gedeo nouns, pitch variations are significant correlates of stress. Vowel length in final position cannot be considered a physical correlate of stress in nouns in their citation form. With regard to intensity, no established pattern is observed. Some of the nouns have higher intensity on their initial and final syllables, many of them have almost identical loudness and some others have less intensity on their final syllables.

Abbreviations

MDLV	Mean Duration of Long Vowels
MDSV	Mean Duration of Short Vowels
MDVWF	Mean Duration of Vowels Word Finally

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Appendix: Recorded Words

	Word	Gloss
1.	ʔil:ɛ	Eye
2.	ʔis:ɔ	Teeth
3.	t'ila	umbrella
4.	hedɛ	there is
5.	mɛʔɛ	he, it went
6.	kɛʔɛ	he, it stood
7.	mala	way out
8.	matʃaɔ	intoxication
9.	faratʃ:ɔ	Horse
10.	gɔsa	tribe
11.	bɔga	country
12.	gɔga	skin
13.	hudʒɛ	job/work
14.	ʔu:mɔ	head/hair
15.	bunɔ	Coffee
16.	ʔunu:na	breast
17.	bu:rɔ	butter
18.	sɔ:dɔ	tomorrow
19.	ʔɔ:sɛ	children
20.	ma:la	Meat
21.	ma:tʃɔ	What
22.	sɛ:m:a	Cloth
23.	t'ɛ:na	Rain
24.	sɛ:ra	guiding principle
25.	sibi:la	Metal
26.	gi:s:a	way of doing something
27.	gɛd:ɛtʃɔ	sheep (sing.)
28.	kɔrbe:s:a	sheep (sing.) (young)
29.	rɛʔɛ	goat
30.	sano	nose

31.	gəɔɔba	belly
32.	nas:ɛ	Soul
33.	gulubə	Knee
34.	ʔanga	Hand
35.	lɛk:a	Foot
36.	ʔan:ɔ	Child
37.	ʔama	mother
38.	ʔan:a	Father
39.	sə:da	relative of a spouse
40.	wə:deʔɛ	Water
41.	tikə	Pen
42.	mine	House
43.	hak':ɛ	Wood
44.	habil:ɛ	knife
45.	wəltʃə	Dog
46.	lamba	kerosene
47.	gi:ra	Fire
48.	ʃana	cabbage
49.	munde	Blood
50.	su:m:ɛ	Lip
51.	dal:ɔ	hump
52.	ʔən:a	Heart
53.	ʔarab:ɔ	tongue
54.	k'ɛ:sitʃ:i	the priest
55.	pəlisitʃ:i	the police(wo)man
56.	mandʒitʃ:i	the man
57.	sajitʃ:i	the cow
58.	kɛ:dantʃ:i	tiger
59.	bɛlti	the boy
60.	ʔisi	he, it
61.	ʔati	you (sing.)
62.	mit:ɛ	One

63.	lame	Two
64.	sase	Three
65.	ʃɔ:le	Four
66.	ʎɔnde	Five
67.	dʒa:ne	Six
68.	tɔrba:ne	Seven
69.	sad:eta	Eight
70.	sal:ane	Nine
71.	tɔm:ɛ	Ten
72.	lankama	yunt (the sister of someone's mother)
73.	ʎadada	yunt (the sister of someone's father)
74.	bagɛdɔ	Spear
75.	mɛʃ:ɛ	Pot
76.	had:ɔtɔ	Bile
77.	k'ɔma	Chest
78.	dudur:ɔ	Back
79.	mad:um:a	Intestine
80.	tʃ'ik'ile	Shoulder
81	mɛla:l:ɛ	Women