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Research Article

A PHONETIC ANALYSIS OF THE VOWELS IN BAAN LANGUAGE

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Abstract

Baan is an Ogonoid language within the Delta Cross language family of the Benue-Congo sub-phylum spoken in Tai local government area of Rivers state, Nigeria. Although Baan is a distinct language within the Ogoni group, it remains the least investigated when compared with other Ogonoid languages such as Eleme, Gokana, Kana, and Tee. This paper sets out to identify and undertake a phonetic analysis of Baan vowels. The data were elicited through personal interviews using the 1700 SIL Comparative African Wordlist. The linguistic consultants included six competent native speakers of Baan, within the age bracket of 35 – 60. Acoustic vowel qualities of formant one (F1) and formant two (F2) values were measured and analyzed using the Praat software, while the phonetic transcription was done with careful and multiple playbacks of the recorded sounds collected with the aid of Wavepad and Audacity audio recording and editing software. The phonemic analysis was done using the principle of minimal pair contrast. The findings revealed that like other Ogonoid languages, Baan records seven oral vowel phonemes /i e ɛ ɑ ɔ o u/ and five nasal counterparts /ĩ ɛ̃ ɑ̃ ɔ̃ ũ/. Both oral and nasal vowels have long counterparts. Contrasts were established between the short and long vowels, and between the oral and nasal vowels. Furthermore, acoustic analyses ascertained /i e ɛ/ as front vowels, /u o ɔ ɑ/ as back vowels, and the approximate duration of long vowels as almost twice that of short vowels. Contrary to earlier studies that the vowel [a] is a front vowel in Ogonoid, the present study revealed that it is a back vowel in Baan /ɑ/.

Keywords: Acoustic analysis, Baan, Formant frequencies, Ogonoid, Spectrogram, Vowel.

INTRODUCTION

Due to their crucial role in articulating speech, vowels have been a subject of extensive research with broad reaching implications in phonetics, phonology, and communication [6], [19]. Vowels are characterized by acoustic properties, primarily determined by the positioning of the vocal tract during articulation [13]. Formant frequencies, which are the resonant frequencies of the vocal tract, play a pivotal role indistinguishing vowel sounds and can vary substantially across languages. An acoustic investigation of vowels can contribute not only to our understanding of the specific linguistic system but also to the broader field of phonological research [5]. In particular, acoustics offers a powerful tool for delving into the phonetic properties of speech sounds, and provides a means to measure and quantify the phonetic features of vowels, such as formant frequencies and duration, offering valuable insights into the phonological structure of a language. While many well-documented languages have received extensive attention in the field of phonetics, there is a growing recognition of the importance of studying underrepresented and lesser-documented languages. These languages, often spoken by small communities, offer unique insights into the diversity of human speech production and perception. One such lesser-documented language is Baan. The Baan language (ISO code: bvj) belongs to the Ogonoid group of languages within Delta Cross, which in turn is classified under the Cross River branch of the Benue-Congo sub phylum[8],[23], also known as Kegboid[11].Other languages in the group are Eleme, Gokana, Kana, and Tee which are spoken in substantive local government areas whereas Baan is spoken in six communities out of twenty two in Tai local government area of Rivers state, Nigeria.

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Despite being a distinct language within the Ogonoid group, it remains the least investigated. Previous studies [9], [11], [20], [22] claim that the vowel [a] in the Ogonoid languages is a front vowel. There is need for an acoustic analysis to verify this claim as it relates to Baan.

Acoustic phonetics

Phonetics is the field of linguistics that concerns itself with the scientific study of speech sounds. It is primarily concerned with the physical properties of sounds in language, including their articulation (how they are produced), acoustic properties (how they are transmitted as sound waves), and auditory properties (how they are perceived by the human ear). Phonetics studies systematically the possible range of human speech sounds. In doing so, it provides a means of describing and classifying all sounds that the human vocal organs are capable of producing. Traditionally, there are three branches of phonetics; articulatory, auditory, and acoustic phonetics. Our review in this study is centered on acoustic phonetics. Acoustic phonetics is a subfield of phonetics that focuses on the physical characteristics of speech sounds as they travel through the air as sound waves. It employs various methods and tools, including spectrograms, waveforms, and frequency, to analyze speech sounds in terms of their acoustic properties. Spectrograms, which are visual representations of sound waves that show the frequency, intensity, and duration of speech sounds can be used to analyze the acoustic properties of individual speech sounds, as well as the patterns of sound waves produced during connected speech. Acoustic phonetics provides critical insights into how speech sounds are transmitted as complex waveforms, which can be broken down into components such as formants, fundamental frequency (pitch), and amplitude (loudness)[13]. It aids in the quantitative measurement and comparison of these acoustic features across different speech sounds, languages, and dialects, contributing to our understanding of phonetic variation and the acoustic cues that distinguish speech sounds. In essence, acoustic phonetics serves as a bridge between the articulatory and auditory aspects of speech, providing empirical data and quantitative measurements that enrich our understanding of how the physical properties of speech sounds contribute to the intricate system of language. Acoustically, vowels are distinguished by their formants (F1, F2, F3, and F4) which are the distinct frequency bands in the acoustic spectrum [19]. The first two formants, F1 & F2, on the spectrum are crucial in defining the characteristics of the vowel and determining vowel quality. The first formant relates to tongue height, with lower frequencies corresponding to vowels articulated with a higher tongue position. The second formant is sensitive to the shape of the body of the tongue or part of the body of the tongue used in the production of the vowel, and is associated with tongue backness, with higher frequencies linked to vowels pronounced farther back in the oral cavity. Front vowels are characterized by the distance between the first two formants. The greater the distance between the two formants, the more front the vowel; the lesser the distance, the more back the vowel [7]. With the aid of computer software, a visual representation of the acoustic spectrum that shows the frequencies of a signal as it varies with time can be used to identify and categorize vowel sounds. A standard for measuring the acoustic properties of vowel [12], [14] has been adopted in this study which is defined by the position of the body of the tongue based on their height and how front or backward they are during production. This standard states that high vowels have a relatively low F1 (estimated at 200Hz – 500Hz). Low vowels have a relatively high F1 (estimated above 500Hz). Back vowels have a relatively low F2 (estimated below2000Hz). Front vowels have a relatively high F2 (estimated above 2000Hz). Front vowels can be determined by considering the distance between F2 and F1; that is, F2 minus F1. The greater the distance between F1 and F2, the more front the vowel. The lesser the distance, the more back the vowel. Central vowels neither have a low nor high F2. Thus, F1 relates to tongue height while F2 relates to tongue position.

Existing works on Baan

Baan first appeared in the literature in 1985[22] where a reconstruction of consonants in C2 positions was carried out for Baan, Eleme, Gokana, and Kana. The study established two morphological distributions for consonants, either as C1 or C2, and ascertained that a C2 consonant is the intervocalic onset in a CVCV syllable. Thereafter, the mutual intelligibility between Baan and Eleme [15] was tested. A critical assessment of the internal classification of the Ogonoid family[4] which includes Baan has also been done. Other available works tend to address the other languages in the Ogonoid family[2], [3], [9], [10], [11], [16], [17], [20]. Baan has been little studied. It has been noted that "structural data on Baan is almost entirely lacking"[4]. Although it is obvious from the existing literature that some work has been done on Baan, there is however, no detailed phonetic or phonemic analysis of Baan vowels. This explains why Baan does not have an orthography. It is to fill this gap that this paper sets out to undertake a phonetic analysis of Baan vowels. The present study is guided by the following objectives;

a) Identify the vowels of Baan,
b) Determine the phonemic status of Baan vowels, and
c) Conduct an acoustic analysis of the vowels.

MATERIALS AND METHODS

Using the SIL Comparative African Wordlist[18], data was elicited from six competent native speakers of Baan within the ages of 35 – 60. The Wavepad and Audacity software enabled the audio recording and editing of sound files while transcription was done with careful multiple playbacks of the recordings. This enabled the identification of the vowels in the language. The Praat computer software [1] was employed to generate the vowel spectrograms and undertake acoustic analyses. The results derived from Praat were plotted on a Microsoft Excel spreadsheet from which a scatter plot of the vowels was developed. The principle of contrast within the framework of Classical Phonemics was utilized to determine the phonemic statuses of the vowels.

RESULTS AND DISCUSSION

Based on the auditory perception of the data collected, seven oral vowels [i e ɛ ɑ ɔ o u] and five nasal vowels [ĩ ɛ̃ ɑ̃ ɔ̃ ũ] were identified. Two of the oral vowels, [e] and[o] do not have nasal counterparts. Typologically, in languages that contrast oral and nasal vowels, not all the oral vowels have nasal counterparts. The oral vowels are the basic vowels that establish Baan as a seven vowel language. Both vowels are shown in examples (1) and (2) respectively.

(1) Oral vowels in Baan

a. [i]	ìlì	'there'
b. [e]	ērɑ̄	'stop'
c. [ɛ]	ɛ̄gɛ̄	'get'
d. [ɑ]	ɑ̀wɑ̋	'full'
e. [ɔ]	ɔ́rí	'slippery'
f. [o]	ōlō	'you'
g. [u]	ūrī	'blow'

(2) Nasal vowels in Baan

a. [ĩ]	mĩ̄	'blood'
b. [ɛ̃]	gɛ̃́	'matchete'
c. [ɑ̃]	bɑ̃́	'feather'
d. [ɔ̃]	tɔ̃́	'ear'
e. [ũ]	mũ̀mũ̀	'fist'

In addition to this vowel inventory, Baan exhibits long vowel counterparts for each oral and nasal vowel as seen in examples (3) and (4) respectively.

(3) Long oral vowels in Baan

a. [i:]	zíí	'oath'
b. [e:]	dēē	'day'
c. [ɛ:]	lɛ́ɛ́	'leg'
d. [ɑ:]	gbɑ̀ɑ̀	'belly'
e. [u:]	búú	'mat'
f. [o:]	bóó	'fruit'
g. [ɔ:]	sɔ́ɔ́	'song'

(4) Long nasal vowels in Baan

a. [ĩ:]	mpĩ́ĩ̄	'penis'
b. [ɛ̃:]	nɛ̃́ɛ̃̄	'liver'
c. [ɑ̃:]	kɑ̃́ɑ̃́nĩ̄	'firewood'

d. [ɔ̃ː]	kɔ̃̄ɔ̃̀	'spear'
e. [ũː]	bũ̄ũ̄	'pus'

Based on auditory perception, the total number of vowels identified are twenty four consisting of seven short oral vowels, seven long oral vowels, five short nasal vowels, and five long nasal vowels. The seven short oral vowels are considered to be the basic vowels from which all the other vowels are derived.

Phonemic analysis of Baan vowels

In order to determine the phonemic status of the vowels, the principle of contrast was applied by providing all the possible minimal pairs for the vowels. This established the seven short oral vowels /i e ɛ ɑ ɔ o u/ as phonemes in Baan.

(5) Minimal pair test of Baan oral vowels

a. /i/vs /e/:	írā	'taste'	érá	'stop'
b. /i/ vs /ɛ/:	kárì	'drip'	kārɛ̀	'drop'
c. /i/ vs /ɑ/:	bī	'vagina'	bɑ́	'hand'
d. /i/ vs /ɔ/:	pīrì	'small'	pɔ́ró	'bad'
e. /i/ vs /o/:	kórí	'leak'	kōrō	'hole', 'hollow'
f. /i/ vs /u/:	írā	'taste'	ūrà	'blow' (of wind)
g. /e/ vs /ɛ/:	tē	'tree'	tɛ̀	'father'
h. /e/ vs /ɑ/:	dè	'eat'	dɑ̀	'lick'
i. /e/ vs /ɔ/:	kpē	'tasty'	kpɔ̄	'vomit'
j. /e/ vs /o/:	ǹdé	'meat'	ǹdó	'salt'
k. /e/ vs /u/:	dè	'eat'	dù	'come'
l. /ɛ/ vs /ɑ/:	ɛ́gɛ́	'get'	ɑ̀gɛ̄	'hardship'
m. /ɛ/ vs /ɔ/:	tɛ̀	'father'	tɔ̄	'house'
n. /ɛ/ vs /o/:	kɛ́rɛ̀	'beans'	kōrō	'hole', 'hollow'
o. /ɛ/ vs /u/:	kɛ́rɛ̀	'beans'	kúrɛ̄	'gather'
p. /ɑ/ vs /ɔ/:	dɑ̀	'lick'	dɔ̀	'fail'
q. /ɑ/ vs /o/:	dɑ̀	'lick'	dō	'measure'
r. /ɑ/vs /u/:	ɑ̄	'yawn'	ù	'die'
s. /ɔ/ vs /o/:	dɔ̀	'fail'	dō	'measure'
t. /ɔ/ vs /u/:	ɔ́rí	'slippery'ūrī	'blow'	
u. /o/ vs /u/:	dō	'measure'	dù	'come'

In some languages, nasal vowels are phonemic (for example, Urhobo and Yoruba), while in other languages such as Igbo and Hausa, they are allophones of their oral counterparts. Contrasts between the short oral vowels and their nasal counterparts were also established in Baan via minimal pairs. For economy of presentation, only the contrasts between the short oral and nasal vowels are shown in example (6), since what applies to the short nasal vowels also applies to their long counterparts.

(6) Contrasts between oral and nasal vowels in Baan

a. /i/ vs /ĩ/:	ǹsī	'housefly'	ǹsĩ́	'face'
b. /ɛ/ vs /ɛ̃/:	kpɛ̀	'path'	kpɛ̃́	'pay' (for something)
c. /ɑ/ vs /ɑ̃/:	bɑ́	'hand'	bɑ̃́	'feather'
d. /ɔ/ vs /ɔ̃/:	tɔ̄	'house'	tɔ̃́	'ear'
e. /u/ vs /ũ/:	dù	'come'	dũ̀	'tail'

Baan also exhibits contrasts between the short and long oral vowels as shown in example (7).

(7) Contrasts between short and long vowels in Baan

a. /i/ vs /iː/:	sī	'market'	síī	'famine'
b. /e/ vs /eː/:	dē	'eat'	dēē	'day'
c. /ɛ/ vs /ɛː/:	fɛ̄	'kill'	fɛ́ɛ́	'drop'
d. /ɑ/ vs /ɑː/:	bɑ́	'hand'	bɑ̀ɑ̀	'two'
e. /ɔ/ vs /ɔː/:	zɔ́	'wealth'	zɔ̀ɔ̀	'python'
f. /o/ vs /oː/:	wō	'so'	wōō	'five'
g. /u/ vs /uː/	dù	'come'	dúū	'dust'

Based on the principle of contrast, using the minimal pair test, the analyses show that Baan has seven oral short vowel phonemes /i e ɛ ɑ ɔ o u/ that contrast with their corresponding seven oral long vowels /iː eː ɛː ɑː ɔː oː uː/, and five short nasal vowels /ĩ ɛ̃ ɑ̃ ɔ̃ ũ/ with corresponding five nasal long vowels /ĩː ɛ̃ː ɑ̃ː ɔ̃ː ũː/. The nasal vowels contrast with their oral counterparts and are thus phonemic. The long vowels contrast with their short counterparts and are also phonemic.

Acoustic analyses of Baan vowels

Acoustic investigations were done in order to ascertain some phonetic qualities of the basic seven oral vowel phonemes, which include formant frequencies and duration. A spectrographic analysis was carried out with the aid of Praat using the data set presented in example (1). The words contained the vowels to be investigated in word-initial position to minimize any assimilatory effects of preceding sounds. The wave forms and spectrograms of the vowels /i e ɛ ɑ ɔ o u/ are presented in figures 1 and 2. The visible dark patches on the spectrograms show the concentration of acoustic energy around a particular frequency in each speech wave. The red dotted lines show the different formants F1, F2, F3, and F4 (arranged from bottom to top of the spectrogram) for each sound measured in Hertz (Hz). Our interest however is restricted to the first two formants, F1 and F2.

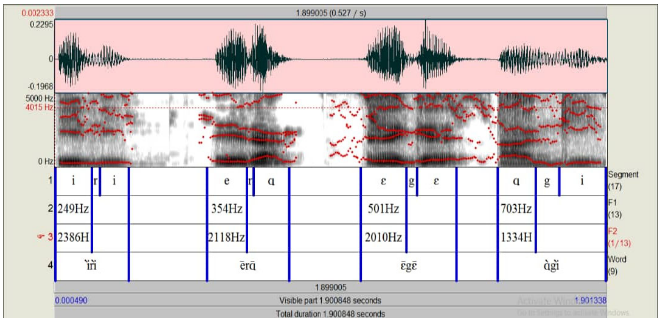

Fig. 1. Spectrograms and formants of vowels [i e ɛ ɑ]

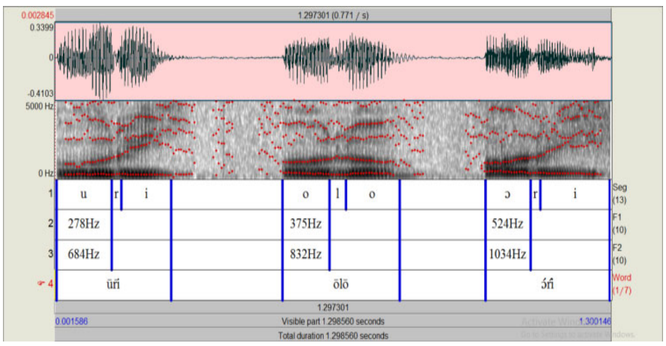

Fig. 2. Spectrograms and formants of vowels [u o ɔ]

The F1 and F2 values from the spectrographic analyses are provided on table 1. The F1 correlates were deducted from F2. The resultant F2-F1 values were plotted against the F1 correlates using a spreadsheet and used to derive a scatter plot shown in figure 3.

Table 1. Formant values of the vowels in Baan

Vowel	i	e	ɛ	ɑ	ɔ	o	u
F2	2386	2118	2010	1334	1034	832	684
F1	249	354	501	703	524	375	278
F2-F1	2137	1764	1509	631	510	457	406

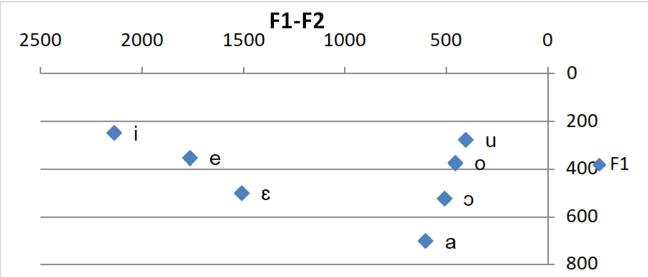

Fig. 3. A scatter plot of Baan vowels

The F1 axis correlates with the tongue height (high, mid, low), while the F2-F1 axis correlates with the tongue position (front, central, and back). On the F1 axis, /i u/ are high vowels (with varying degrees of height), /e ɛ o ɔ/ are mid vowels while /ɑ/ is a low vowel. Consequently, on the F2-F1 axis, we have as front vowels /i e ɛ/ and as back vowels /u o ɔ ɑ/. Based on these acoustic parameters, the basic seven vowel phonemes of Baan are represented on the traditional vowel chart as shown on figure 4.

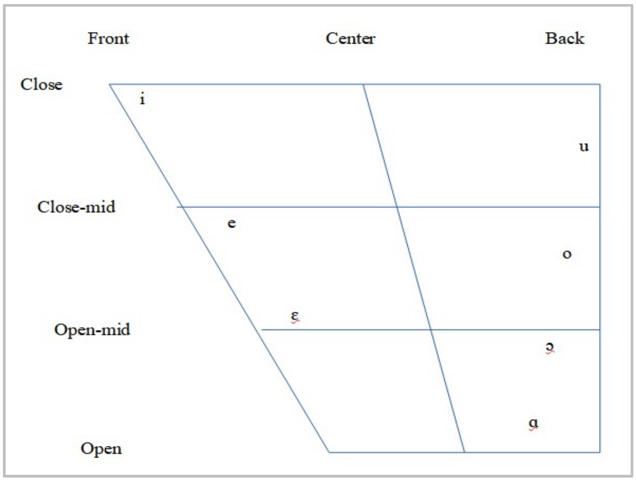

Fig. 4. Baan vowel chart

In addition to the vowel qualities already established via acoustic analysis, a difference in the duration of short and long vowels was also ascertained as shown in figures 5, 6, 7 and 8.

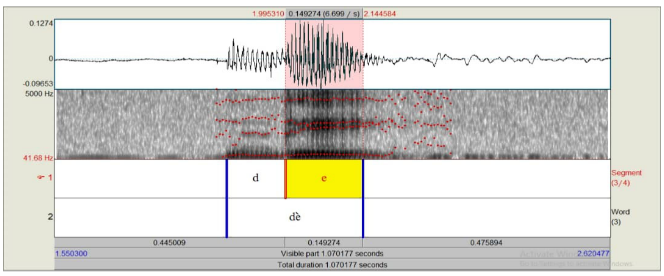

Fig. 5. Duration of /e/

The duration between /eː/ at 0.247312 secs and /e/ at 0.149274 secs showed a difference of 0.098038 secs while the difference between /ɑː/ at 0.218738 secs and /ɑ/ at 0.101907 secs was 0.116831 secs. The duration of the short vowels and the difference between the short and long vowels is approximately 0.1 secs. The average duration of long vowels is almost twice that of short vowels [21]. This further verifies the perception that there is a difference between short and long vowels in Baan.

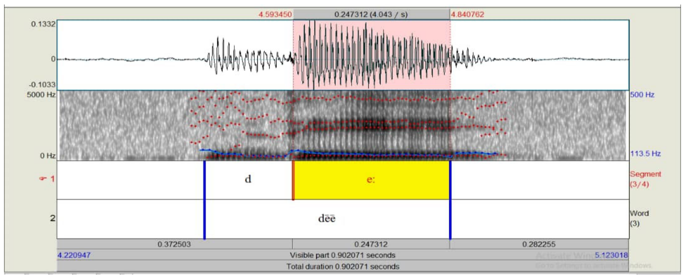

Fig. 6. Duration of /eː/

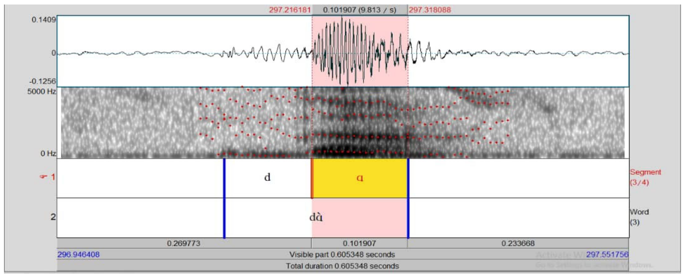

Fig. 7. Duration of /ɑ/

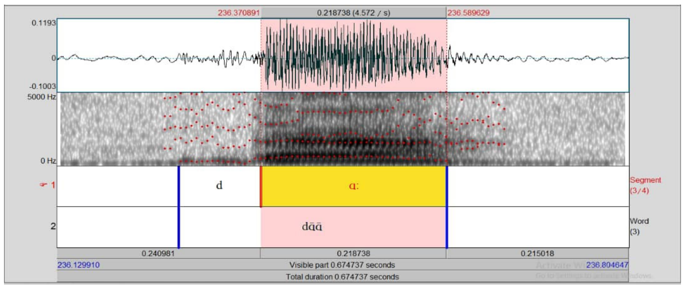

Fig. 8. Duration of /ɑː/

Conclusion

Baan is a lesser described Ogonoid language (Benue-Congo) spoken in Tai local government area of Rivers state, Nigeria. The present research, which is a first in Baan language, was aimed at describing the vowels of the language by providing an acoustic analysis of the vowel properties and ascertaining the vowel phonemes. The study identified seven oral /i e ɛ ɑ ɔ o u/ and five nasal /ĩ ɛ̃ ɑ̃ ɔ̃ ũ/ vowel phonemes in Baan which is in line with the vowel systems of other Ogonoid languages. Two of the oral vowels /e o/ do not have nasal counterparts. In addition, the study observed that the oral and nasal vowels contrast with long vowel counterparts giving rise to seven long oral vowels /iː eː ɛː ɑː ɔː oː uː/ and five long nasal vowels /ĩː ɛ̃ː ɑ̃ː ɔ̃ː ũː/. Contrasts between the short and long vowels, and between the oral and nasal vowels were established by providing minimal pairs. A spectrographic analysis of the vowels with the aid of the Praat software revealed /i e ɛ/ as front vowels and /u o ɔ ɑ/ as back vowels. Contrary to earlier claims[9], [11], [20], [22]that in Ogonoid languages, [a] is a front vowel, the acoustic findings of this work show [a] to be a back vowel /ɑ/ in Baan. Furthermore, the spectrograms show that the approximate duration of long vowels in Baan is almost twice that of short vowels. This finding corroborates what is in the literature [21] and further confirms the phonemic analysis that contrasts short and long vowels based on minimal pairs. In conclusion, this study has provided valuable insights into the vowel properties of this linguistically distinct and lesser-documented language. Through phonetic analysis, we have documented the acoustic characteristics of Baan vowels, addressed issues of phonemic inventory, and contributed to studies in Ogonoid linguistics as well as linguistic typology. The study recommends further research into other aspects of the sound system to enable the development of an orthography for Baan.

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