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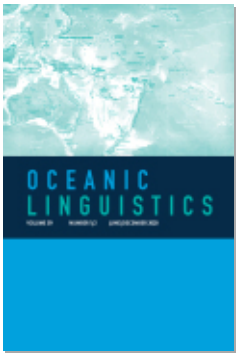

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Breathy Vowels Are Not Phonemic in Kedang (Eastern Indonesia)

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Breathy phonation refers to the laryngeal setting where the vocal folds are less tense and make less contact than in "modal" phonation, which consequently leads to continuous leaking of voiceless airflow, giving rise to the perception of breathiness in a speech sound. In Austronesian languages, contrastive breathy segments are very rare. For the Austronesian languages of Island Southeast Asia, only one language has been reported to have phonemically breathy vowels: Kedang, a language spoken on Lembata island, in eastern Indonesia. In this paper, we revisit the earlier analysis that in Kedang, breathiness distinguishes phonemic "breathy" from "modal" vowels. Presenting evidence of distributional, acoustic, and etymological nature, we argue that the so-called breathy onsetless vowels do not appear to be similar to breathy vowels described in the literature. Their "breathy" nature may have a historical source in initial glottal consonants that were lost, but is currently used as a phonetic strategy that is intended to enhance the perceptual contrast between syllables with a phonemic glottal onset versus onsetless syllables. We also suggest that the glottal stop in Kedang is phonemic in all positions and indicate a possible historical trajectory for its development.

1. INTRODUCTION.[1] The Austronesian language Kedang is spoken by approximately 29,000 speakers in the eastern part of Lembata island, in eastern Indonesia (see figure 1).

Kedang shows a contrast between "true" onsetless initial syllables that start with a vowel that sounds slightly breathy and initial syllables that start with a glottal stop. An illustrative near-minimal pair is presented in figure 2.

In Samely (1991), the first grammatical description of Kedang, the contrast between the first syllables of a minimal pair like the one in figure 2, is analyzed as a contrast between phonemically "breathy" and "modal" vowels in initial position, with the modal vowels being preceded by a phonetic glottal stop.[2]

1. We would like to thank Daniel Kaufman, the editor of Oceanic Linguistics, and the two anonymous reviewers for their insightful suggestions on an earlier draft of this paper. The work of Klamer and Swenne was supported by the VICI research project "Reconstructing the past through languages of the present: the Lesser Sunda Islands" at Leiden University, awarded to Klamer and funded by the Netherlands Organisation for Scientific Research (NWO), project number 277-70-012.

2. The dictionary of Kedang (Samely and Barnes 2013) adopts the same analysis.

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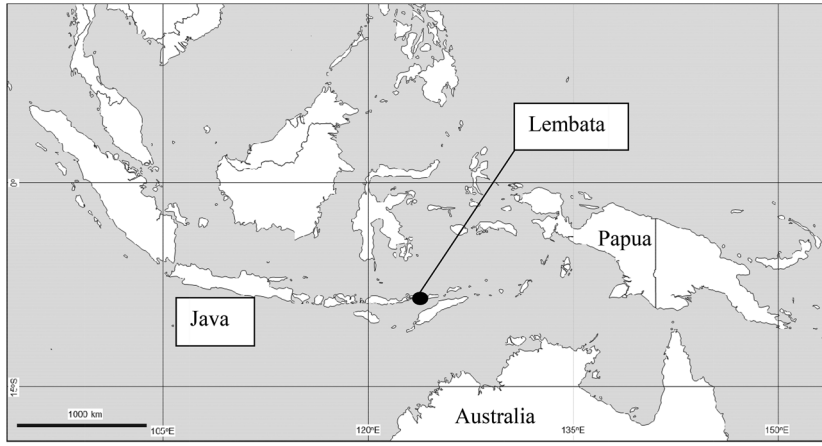
FIGURE 1. LEMBATA ISLAND IN EASTERN INDONESIA, WHERE KEDANG IS SPOKEN

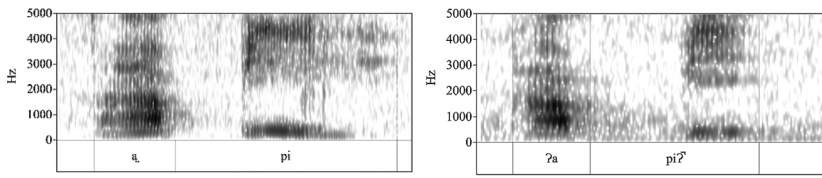


Since then, the Kedang breathy vowels have featured in a cross-linguistic overview of phonation types (Gordon and Ladefoged 2001) and a typological overview of Austronesian languages (Himmelmann 2005:117).

"Breathy" phonation refers to the laryngeal setting in which the vocal folds are less tense and make less contact than in "modal" phonation (Ladefoged 1971; Ní Chasaide and Gobl 1995; Ladefoged and Maddieson 1996; Blankenschip 2002; Johnson 2012), which consequently leads to continuous leaking of voiceless airflow, giving rise to the perception of breathiness in a speech sound.

Breathy voice phonation can be contrastive: numerous languages exhibit contrastive breathy-voiced phonation either on stop consonants, as in Hindi (Ohala 1983; Dixit 1989), Bengali (Khan 2010), and Maithili (Yadav 1984), or on vowels, as in many Zapotec languages (e.g., Jones and Knudson 1977; Munro and Lopez 1999; Esposito 2010). In Austronesian languages, however, contrastive breathy vowels and consonants are very rarely attested. The Chamic languages on the southeast Asian mainland are the only

FIGURE 2. SPECTOGRAMS OF THE MINIMAL PAIR [a̤pi] 'FIRE' AND ʔapiʔ 'WING'



Austronesian group known to date which developed phonemic breathy vowels, and they did this as the result of contact with tonal Mon-Khmer languages (see Thurgood 1999:179–87). There is no evidence of the (historical) presence of tone languages in the region where Kedang is spoken, and none of the other languages in eastern Indonesia has been attested with phonemically breathy vowels.

The earlier analysis in Samely (1991) comes with certain complications: (1) it doubles the Kedang vowel inventory by postulating six modal and six breathy vowels, (2) it introduces a phonemic distinction (breathiness) that is not found in any of the other (Austronesian and non-Austronesian) languages in the region, and (3) it lacks a historical explanation on how Kedang could have developed this unique feature.

In the present paper, we revisit the issue of phonemic breathy vowels in Kedang and propose an alternative analysis that is more parsimonious, is more in line with the phonetics and phonologies of related languages, and aligns better with the historical trajectories of their sounds. Presenting evidence of distributional (section 3), acoustic (section 4), and etymological (section 5) nature, we argue that the so-called breathiness perceived in the onsetless vowels of Kedang may have a historical source in initial glottal consonants but is currently used as a phonetic strategy that is intended to enhance the perceptual contrast between syllables with a phonemic glottal onset versus onsetless syllables. We also suggest that the glottal stop is phonemic in all positions and indicate a possible historical trajectory for its development.

2. METHODS. The research on which Samely (1991) is based took place in 1984 and 1985–1986 in the village of Leuwayang, located to the west of the volcano on Lembata island, with occasional visits to other Kedang-speaking villages. Samely's materials were based on four individuals: one recording of a 56-year-old male Kedang speaker, produced in Jakarta, in a sound-proof booth, using a Revox PR 99 reel tape recorder; and three different male speakers on cassette recordings obtained under field conditions. The Jakarta recording includes 76 minimal or near-minimal word pairs and 64 minutes of read and freely narrated texts. None of the content of these recordings is further specified (Samely 1991:5, 13).

In May 2015 the first author visited the Kedang village Leubatang, located just a few kilometers from the village Leuwayang where Samely had collected her data in the 1980s. The aim of this 2015 field trip was not to do phonetic research, but to carry out a lexical and cultural survey. For the lexical survey, we collected a word list for 585 different concepts. These included basic vocabulary (roughly the 200-item Swadesh list), region-specific vocabulary (e.g., "betelnut," "lime," "corn," "sweet potato," "rice field," "bride price," "dowry," "machete," and "mosquito"), and highly borrowable vocabulary relating to semantic domains such as religion and belief, clothing and grooming, as well as food and drink (see Haspelmath and Tadmor 2009).

The word list was collected and recorded in the following way. First, the words were elicited using Indonesian, as this is the national language and language of education that is spoken as a second language by all Kedang speakers. In this initial phase of word collection, an Indonesian student research assistant, in consultation with 6–8 male adult Kedang speakers, spent an afternoon and evening going through the Indonesian word list word by word, asking for the Kedang equivalent of each word. The consensus response to each of the items was noted down in International Phonetic Alphabet (IPA). The correctness of the transcription was checked by repeating the word several times, while inviting the native speaker consultants to correct any mispronunciations. Based on the literature on Kedang (Samely 1991; Samely and Barnes 2013), we were particularly interested in noting any possible auditory and articulatory difference between words with an initial glottal stop, and words with an initial onsetless syllable. Any native speaker corrections were incorporated into the IPA transcription.[3] The next day, one 48-year-old male Kedang speaker, who had also been present at the word collection phase, was recorded on both video and audio. During the recording, the assistant first read out the Indonesian prompt, and the Kedang speaker uttered the Kedang equivalent, repeating it twice. While he was uttering the Kedang words, the first author double-checked their IPA transcriptions that had been made during the collection phase, again paying particular attention to the difference between words with an initial glottal stop, and words with an onsetless initial syllable. Note that because the aim of the survey was to collect a word list, the words were not recorded in a carrier sentence. In this way, we recorded $585 \times 2 = 1{,}170$ Kedang words. The materials used in the present study were recorded using a Roland R-05 recorder, sample rate: 48.0 kHz, Rec Mode: WAV-24bit. A few days later, the recording was transcribed in "broad" IPA.[4] The video and audio recordings of the Kedang word list, as well as a copy of the original transcription, are available at The Language Archive (TLA) https://archive.mpi.nl/islandora/search/Kedang?type=dismax (Accessed 25 May 2020). The word list is also part of the online Open Access *LexiRumah* database (https://lexirumah.model-ling.eu/lexirumah/, Kaiping and Klamer 2018; Kaiping, Edwards, and Klamer 2019).

Being based on clear, unambiguous native speaker judgments, in conjunction with our own auditory observations on three different occasions (i.e., at the

3. A reviewer noted that glottal stop acoustics can vary quite a bit within a language, and even within speakers, raising the question how we determined the presence versus absence of a glottal stop in Kedang words. In our survey, this was done using native speaker judgments in the setting described above. Speakers of a language where the glottal stop is as meaningful as the other obstruents (e.g., Kedang and many of its relatives in eastern Indonesia) do not appear to show any hesitation whatsoever to point out the presence versus absence of a glottal stop. They are very confident in correcting words that are missing their glottal onset, or words that are pronounced with a glottal onset but should not have one—just like an English speaker would be confident correcting anyone mispronouncing the word *kit* as "*it";* or saying "*pant"* for the word *ant.*

4. A "broad" IPA transcription is not expected to convey more detail than available using any basic IPA letter (vowels and consonants), and the symbols for "long" (ː), "primary stress" (ˈ), "nasalized" (~), and "syllable break" (.).

collection phase, at the recording phase, and when listening back to the recording), we were confident to use our transcribed Kedang word list to classify words into three separate categories: (1) words starting with a glottal stop, (2) words starting with a vowel, and (3) words starting with other obstruents. However, we were less sure about the exact acoustic nature of the initial vowels, in particular because they had been reported as "breathy" by Samely (1991), something that our auditory impressions could not clearly confirm. For this reason, we decided on a more detailed acoustic analysis of the Kedang vowels, focusing on the question to which extent the allegedly "breathy" sounding vowels are acoustically different from the modal vowels, and whether their differences qualify as phonemic contrast between breathy and modal vowels as Samely (1991) claimed. Upon contacting Samely for her original recordings, we learned that they had been lost, so we only had our own field recordings to analyze. This analysis was done in the Netherlands over the course of 2017–19.

From the 1,170 words recorded in 2015, the first of each pair of words was selected—except when the first one had more background noise than the second (e.g., because of a rooster crowing in the background), in which case the second utterance was selected. If both utterances were too noisy, the pair was removed from the set of materials. In this way, 389 words were selected for further analysis and cut out from the original recording using Adobe Audition 3.0. Of these 389 words, we selected for further study 204 words starting with either an initial "breathy"-like vowel or a CV (ʔV, pV, tV, kV) syllable. These words are listed in the appendix. The total number of investigated vowels is presented in table 1, according to their context.

The vowels of the initial syllables were segmented using Praat (Boersma and Weenink 2016). Acoustic characteristics of the vowels were measured using VoiceSauce (Shue et al. 2011) with the following options: F0 (straight with a range of 50–300 Hz), Formants (Praat) for F1, and vowel spectral tilt *H1*–H2** (corrected values over the closed quotient of the vowel with a 25 ms window size). We took *H1*–H2** as an indicator of breathiness, which was reported in Samely (1991) for Kedang and also for many languages in Blankenschip (2002). In total, four sets of acoustic measurements were

TABLE 1. NUMBER OF INVESTIGATED VOWELS ACCORDING TO CONTEXT IN WHICH THEY APPEARED

	V	no.	ʔV	no.	kV	no.	tV	no.	pV	no.	Total
	i̤	5	*ʔi*	7	*ki*	3	*ti*	3	*pi*	6	24
	e̤	3	*ʔe*	9	*ke*	4	*te*	6	*pe*	2	24
	ɛ̤	3	*ʔɛ*	7	*kɛ*	–	*tɛ*	4	*pɛ*	4	18
	a̤	13	*ʔa*	14	*ka*	12	*ta*	11	*pa*	12	62
	o̤	6	*ʔo*	11	*ko*	–	*to*	3	*po*	7	27
	ṳ	12	*ʔu*	9	*ku*	3	*tu*	10	*pu*	15	49
Total		42		57		22		37		46	204

extracted: the vowel duration (in ms), the fundamental frequency (f0 in Hz), the first formant (f1 in Hz), and spectral tilt (*H1*–H2** in dB). For the latter three parameters (i.e., f0, f1, and *H1*–H2**), we measured at nine equidistant points over the vowel interval. We further derived the mean f0, f1, and *H1*–H2** at three time points (i.e., initial, medial, and final). The initial value was derived by averaging the values taken at the first and second time points; medial over the fourth and fifth points; and final over the eighth and ninth points.

3. DISTRIBUTION OF KEDANG VOWELS AND GLOTTAL STOP.

Of the words in the corpus collected by Samely, 4.18 percent are monosyllabic (C)V(C), 94.72 percent disyllabic (C)V.(C)V(C), and 1.10 percent trisyllabic (Samely 1991:44–45). The Kedang vowels [a, ɛ, æ, i, ɔ, u] are further classified in Samely (1991) as either "modal" or "breathy." To support the proposed "breathy" versus "modal" contrast, the minimal pairs in table 2 are presented (Samely 1991:14):[5]

The "modal" and "breathy" vowels are not equally distributed: "breathy" vowels only occur in word-initial syllables without an onset, while "modal" vowels can occur in word-initial, medial, and final syllables (Samely 1991:49).

The Kedang consonants include six phonemic stops: /p, b, t, d, k, g, ʔ/ (Samely 1991:36–7). All stops occur as an onset of word-medial syllables. In Samely (1991), word-initial glottal stops are analyzed as nonphonemic. However, we analyze all stops, including the glottal, as phonemic in word-initial as well as word-medial position. The glottal stop is the only consonant that occurs as word-final coda.

In Samely's analysis, word-initial syllables in Kedang consist of either (1) a consonant and a "modal" vowel or (2) an onsetless "breathy" vowel or (3) an optional initial phonetic glottal stop followed by a "modal" vowel (Samely 1991:53, 222). That is, the words with modal vowels in the left-side column of table 2 are assumed to occur either with a phonetic glottal stop or without one.[6] This optional initial glottal stop is not found in our data. In our data, an initial syllable with a modal vowel always has an onset (glottal stop or other consonant). One could speculate about the reason of the discrepancy between Samely's findings and those of the present paper. It may be the case that over the ~30-year period between Samely's and our work the language has changed so that analogous to the initial glottal stops that historically derived from a phonemic stop consonant /k/ in a restricted number of words (see table 6), all glottal stops phonemicized in all word-initial contexts.

5. The source also mentions that an additional set of 48 words (4 words for each of the 12 Kedang vowels) was examined phonetically, but this additional set of words remains unspecified. For reasons of legibility, we have adapted the orthography used in Samely (1991) to follow IPA conventions, in particular replacing *y* with [j], *q* with [ʔ], and transcribing the breathy vowels in IPA instead of having them preceded by '>', as in the original source. For example, original *>iu* 'crocodile' is transcribed here as [i̤u] 'crocodile'.

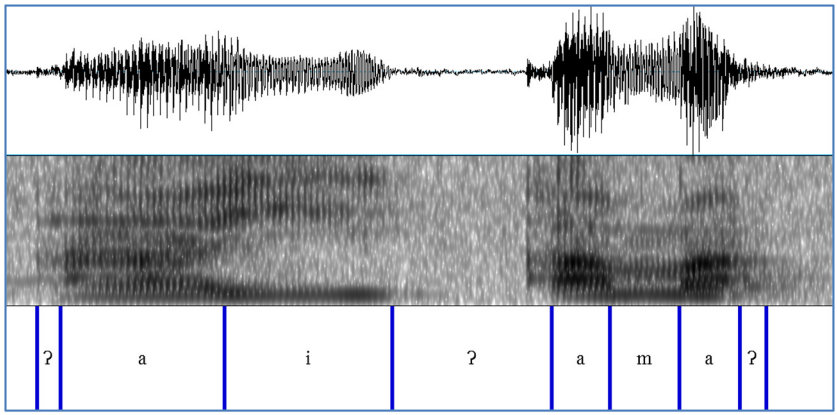
6. Samely mentions the examples /iraʔ/ 'swallow' realized as either [iraʔ] or [ʔiraʔ], and /iʔir/ 'pus' realized as either [iʔir] or [ʔiʔir].

TABLE 2. MINIMAL PAIRS WITH INITIAL "MODAL" AND "BREATHY" VOWEL

Modal vowels		Breathy vowels	
[iu]	'cook'	[i̪u]	'crocodile, shark'
[ɛrɛ]	'quiet'	[ɛ̪re]	'fishing tackle'
[ævin][†]	'yesterday'	[æ̪vɔl]	'ash'
[apɛ]	'cotton'	[a̪pe]	'what'
[ɔtɛ]	'that'	[ɔ̪tɛ]	'over there'
[uʔ]	'take'	[u̪ʔ]	'behind'

[†] In our data, the words represented with [v] in this table are pronounced with a labiodental [ʋ].

FIGURE 3. SPECTROGRAM OF GLOTTAL STOP-INITIAL ʔamaʔ 'BARK' INSIDE A COMPOUND: /ʔaiʔamaʔ/ [ʔaiˈʔamaʔ] 'TREE BARK' (LIT. WOOD BARK')[7]

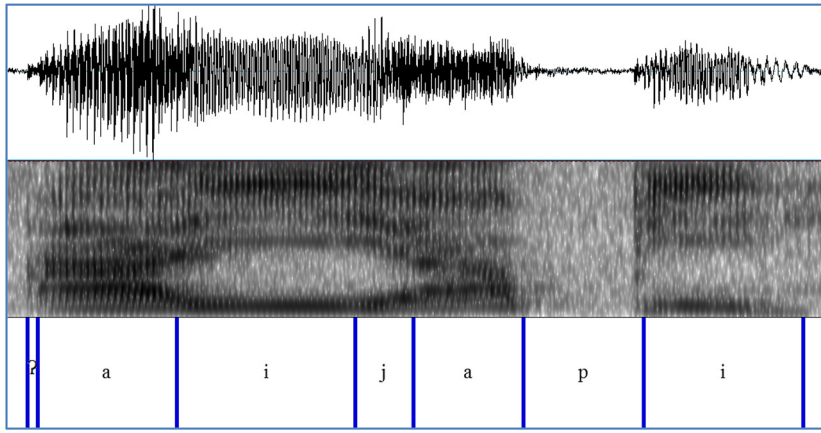


Our data confirm Samely's observation that vowels with a "breathy" nature are not preceded by a glottal stop (some apparent counterexamples are discussed in section 5). All of this suggests an analysis in which today, the initial glottal stop in Kedang is phonemic—just as it is phonemic in word medial and word final position—and the "breathy" nature of initial vowels signals the lack of an onset.

Due to the nature of a word list, most of our data are words produced in isolation, or at the beginning of an utterance. This raises the question whether the initial glottal might be a phonetic feature of utterance-initial words. Our data also contain two-word compounds and phrases, and in such contexts, if

7. For the initial glottal and final stops, we have only marked the glottal release/incomplete closure, while for the medial, we have marked the glottal stop to include both the closure and the release.

FIGURE 4. SPECTROGRAM OF VOWEL-INITIAL ạpi 'FIRE' INSIDE A COMPOUND: /ʔai api/ [ʔaiʲjapi] 'FIREWOOD' (LIT. 'WOOD FIRE')



the second word is a word with an initial glottal stop, it retains the stop, while a second word that has no initial onset is separated from the first by a hiatus consonant such as [j]. The compounds in figures 3 and 4 illustrate this. In figure 3, the word *ʔamaʔ* 'bark' in the compound *ʔai ʔamaʔ* 'tree bark' (lit. 'wood bark') retains its original glottal stop. In figure 4, *ʔai ạpi* 'firewood' (lit. 'wood fire') the onsetless second word *ạpi* 'fire' is separated from the same preceding word *ʔai* 'wood' with a hiatus consonant [j] in its surface realization, but realized without any glottal closure before the "breathy" vowel.

In sum, the distribution of the Kedang vowels and glottal stop suggests a phonemic contrast between initial syllables with an onset and initial syllables without an onset. In the former type of syllable, the onset can be any consonant, including a glottal stop; and all vowels following this onset sound like normal ("modal") vowels. In the onsetless syllables, the slightly "breathy" phonation of the initial vowel is due to the phonetic enhancement that Kedang speakers employ to signal the contrast between a glottal-onset syllable versus an onsetless syllable.

4. ACOUSTIC EVIDENCE FOR ONSET CONTRAST. In this section, we present the acoustic characteristics of the "breathy" sounding vowels. The main question we focus upon is the extent to which the "breathy" sounding vowels are acoustically different from the modal vowels, and whether their differences qualify as phonemic contrast between breathy and modal vowels as Samely (1991) claimed, or are better characterized as enhanced contrast between onsetless syllables and syllables with a glottal stop onset.

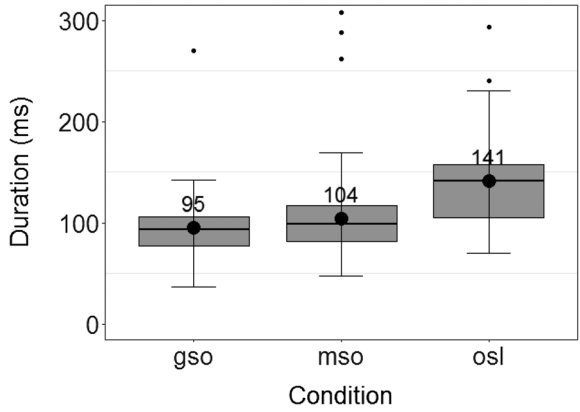
Samely concludes that Kedang breathy vowels differ from modal ones through considerably lower pitch, a lowered f1, longer duration, and relatively more energy in the lower part of the spectrum (Samely 1991:35). In our analysis, as mentioned earlier, we included the same measurements (i.e., duration, f0, f1, and *H1*–H2**). All four acoustic measurements were modeled via linear mixed effects modeling. Given the small size of the data set and the fact that all data were produced by one speaker, we included Item as a random variable (with by-item intercept) and Vowel as a control variable. For vowel duration, we included Condition of syllable onsets as an independent variable with three levels: Onsetless (osl), Glottal Stop Onset (gso), and Miscellaneous Stop Onset (mso). For f0, f1, and *H1*–H2*,* we further included Time Point as another independent variable (with three levels: Initial, Medial, and Final). We were interested in the timecourse of how the cues for breathiness were realized over the vowel interval, to adjudicate whether the effects are better attributed to syllable onsets, which predicts more salient effects at the initial point and decreasing magnitude toward the end of the vowel, or to phonemic vowel contrast, which predicts comparable effects throughout the vowel—if not more salient toward the end of the vowels. Furthermore, the phonemic vowel contrast view would predict that vowels after stop onsets should show a consistent similarity as those occurring after a glottal onset, given that both are modal vowels. They should differ from vowels in onsetless syllables as only the latter are phonemically breathy.

4.1. DURATION. Statistical results showed that Condition had a significant main effect on vowel duration ($\chi^2[5] = 30.11$, $p < .001$), which indicates that the duration of the vowel after different onsets did show differences. Post-hoc tests using Tukey's honestly significant difference (HSD) showed that the mean vowel duration in onsetless syllables (osl; 141 ms) differed from that after a stop onset (osl; 104 ms) ($z = 4.93$, $p < .001$) and a glottal onset (gso; 95 ms) ($z = 5.325$, $p < .001$). There was, however, no significant difference between the gso and mso conditions ($z = 1.180$, $p > .05$). The results thus confirmed the patterns plotted in figure 5 that the duration of the vowel without onset is significantly longer than that after other onsets (i.e., glottal and stop onsets).

4.2 F0. Figure 6 shows the mean f0 of the three time points (1: initial; 2: medial; and 3: final) under each onset condition. Error bars represent the standard error of the mean. Visual inspection suggests that there is a clear f0 difference at the initial portion of the vowels, but the difference minimizes toward the end of the vowel for the onsetless and the miscellaneous stop onset conditions.

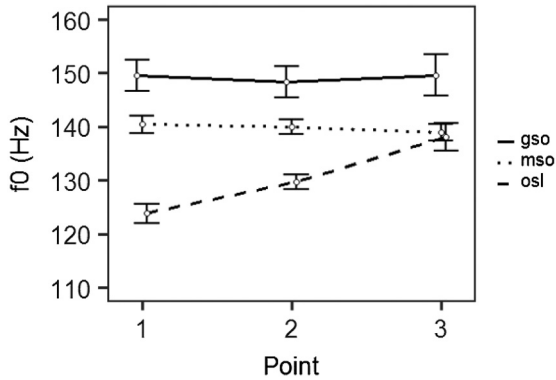
The statistical results confirmed the impressionistic observation. There was a significant main effect of Condition ($\chi^2[5] = 29.22$, $p < .001$) as well as a

FIGURE 5. BOXPLOTS OF THE DURATION OF VOWELS IN TARGET SYLLABLES IN EACH CONDITION. THE SOLID POINT IN THE BOX REPRESENTS THE MEAN AND THE LINE WITHIN THE BOX THE MEDIAN. (GSO = GLOTTAL STOP ONSET; MSO = MISCELLANEOUS STOP ONSETS; OSL = ONSETLESS)



significant interaction of Condition and Time Point ($\chi^2[16] = 32.52$, $p<.001$). Specifically, Condition had a consistent effect on f0 across all three time points (P1: $\chi^2[5] = 49.54$, $p<.001$; P2: $\chi^2[5] = 30.13$, $p<.001$; P3: $\chi^2[5] = 11.13$, $p<.01$). However, Tukey's post-hoc tests showed that although all three

FIGURE 6. MEAN F0 OF THREE TIME POINTS (1: VOWEL INITIAL; 2: VOWEL MEDIAL; 3: VOWEL FINAL) OVER VOWELS IN EACH CONDITION. ERROR BARS REPRESENT THE STANDARD ERROR OF THE MEAN. (GSO = GLOTTAL ONSET; MSO = MISCELLANEOUS STOP ONSETS; OSL = ONSETLESS)

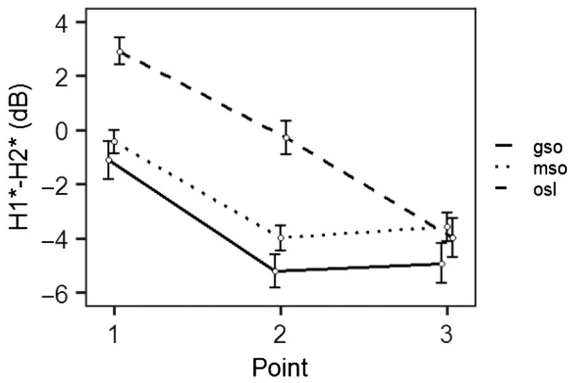


conditions differed from each other at P1 (osl vs. gso: $z = -8.66$, $p < .001$; osl vs. mso: $z = -6.59$, $p < .001$; gso vs. mso: $z = -3.5$, $p < .01$) and P2 (osl vs. gso: $z = -6.14$, $p < .001$; osl vs. mso: $z = -3.93$, $p < .001$; gso vs. mso: $z = -3.26$, $p < .01$], at P3, the contrast between osl and mso disappeared (osl vs. mso: $z = -0.25$, $p > .05$). The other two conditions did remain significantly different (osl vs. gso: $z = 3.69$, $p < .01$; gso vs. mso: $z = -3.52$, $p < .01$).

4.3. *H1*–H2*.* Plotted in figure 7 is the mean *H1*–H2** values as a function of syllable onset at three time points. Here, the effect of onset Condition seems to disappear completely by the final component of the vowel across the three syllable onset conditions.

Statistical results confirmed a main effect of Condition ($\chi^2[5] = 14.9$, $p < .001$), Time Point ($\chi^2[7] = 152.05$, $p < .001$), as well as their interaction ($\chi^2[16] = 30.66$, $p < .001$). Condition showed a significant effect at both P1 and P2 (P1: $\chi^2[5] = 20.44$, $p < .001$; P2: $\chi^2[5] = 27.58$, $p < .001$]. Tukey's post hoc tests indicated that the onsetless condition consistently differed from its two counterparts at both P1 [osl vs. gso, $z = 4.25$, $p < .001$; osl vs. mso, $z = 4.45$, $p < .001$) and P2 (osl vs. gso, $z = 5.06$, $p < .001$; osl vs. mso, $z = 4.9$, $p < .001$). But the glottal onset condition (gso) and the stop onset condition (mso) showed comparable *H1*–H2** (P1: $z = .37$, $p > .05$; P2: $z = .89$, $p > .05$). Focusing upon the time point P3, it is important to note that Condition failed to show any significant effect ($\chi^2[5] = 2.32$, $p > .05$), confirming that the syllable onset-induced *H1*–H2** differences observed at P1 and P2 vanished toward the final portion of the vowel.

FIGURE 7. MEAN *H1*–H2 OVER THREE TIME POINTS (1: VOWEL INITIAL; 2: VOWEL MEDIAL; 3: VOWEL FINAL) OVER VOWELS IN EACH CONDITION. ERROR BARS REPRESENT THE STANDARD ERROR OF THE MEAN. (GSO = GLOTTAL ONSET; MSO = MISCELLANEOUS STOP ONSETS; OSL = ONSETLESS)**



4.4. F1. Results of the analyses on the vowel first formant (f1) indicated that only vowel ($\chi^2[12] = 429.81$, $p < .001$) showed a significant main effect on f1, confirming the well-known formant differences for vowels. There was, however, neither a main effect of Condition ($\chi^2[5] = 0.21$, $p > .05$) nor any significant interaction of Condition with time point ($\chi^2(16) = 6.34$, $p > .05$).

4.5. DISCUSSION OF ACOUSTIC EVIDENCE. In Samely's analysis, breathy vowels differ from modal ones through considerably longer duration, lower pitch, relatively more energy in the lower part of the spectrum, and a lowered first formant (Samely 1991:35). These findings are partly confirmed in our data. In terms of duration, vowels in onsetless syllables (i.e., the so-called breathy vowels) are consistently longer than vowels following a glottal or stop onset. In terms of pitch, vowels in onsetless syllables show consistently lower f0 than those with an onset. The difference, however, disappears toward the end of the vowel in the onsetless and stop onset conditions. Note that Samely (1991) reports the f0 merger of "breathy" and modal vowels toward the end of two vowel sets (i.e., the breathy vs. modal vowel /i a/). Thus, while the details of the findings are different between the two studies, what has converged between the two studies is the lack of steady f0 differences over the time course of the so-called breathy and modal vowels.

We also found amplitude differences between the first and second harmonics (H_1*–H_2*) for vowels in onsetless syllables, compared to those with glottal and obstruent onsets. The H_1*–H_2* difference, however, does not remain throughout the vowel, as predicted by the phonemic vowel contrast view. More specifically, on the one hand, vowels in onsetless syllables indeed have breathier quality than that with either glottal or stop onsets. On the other hand, the greater spectral tilt of breathiness diminishes and drops to around zero after the midpoint. This difference does not correspond with the characteristics described by Samely (1991) and mentioned by Gordon and Ladefoged (2001) as typical for breathy vowels: that H_1–H_2 relates to spectral tilt, and breathy voice should show a larger "fall-off" in energy than modal voice, which manifests itself in *positive* values for breathy vowels against negative vowels for modal ones. Furthermore, toward the end of the vowel (i.e., at the P3 time point), the H_1*–H_2* difference disappeared completely across the three onset conditions. Lastly, while Samely (1991) reports a lowered first formant for "breathy" vowels, we did not find any significant difference in f1in our data. Conjointly, our findings raise serious doubts to the proposal that the observed acoustic differences across the three onset conditions should be attributed to phonemic vowel contrast between breathy and modal. Instead, the tapering acoustic differences suggest that these cues are better interpreted as an enhancement strategy to mark the contrast between onsetless syllables and syllables with a glottal onset (in the same spirit as the enhancement of features discussed in Stevens and Keyser 1989).

TABLE 3. KEDANG REFLEXES OF VOWEL-INITIAL PMP FORMS (BLUST AND TRUSSEL 2010)

Kedang	Proto-Malayo-Polynesian	Gloss
ɛnɛŋ	*enem	'six'
apaʔ	*epat	'four'
anaʔ	*anak	'child'
au	*asu	'dog'
ɛʔi	*aku	1SG
ame	*ama	'father'
ine	*ina	'mother'

5. ETYMOLOGY OF "BREATHY" VOWELS AND INITIAL GLOTTAL STOPS IN KEDANG. This section examines the history of the initial "breathy" vowels and glottal stops in Kedang. Many of the words with an initial vowel that sounds somewhat "breathy" are reflexes of Proto-Malayo-Polynesian (PMP) forms with onsetless initial vowels; examples are given in table 3.

In our data, some of the words that are etymologically vowel-initial (e.g., *ame* 'father', *ine* 'mother', and *api* 'fire') are pronounced alternatively with either an onsetless vowel or an initial glottal stop. This is illustrated for *ame* 'father' in figures 8 and 9. In figure 8, *ame* 'father' is used as the second member of a compound and is vowel-initial. In figure 9, it is the initial word of an utterance and is realized with an initial glottal stop. We consider this variation in pronunciation in some of the vowel-initial words to be phonetic, occurring when the word is the initial word of an utterance. In addition, the glottal stop pronunciation stop in [ʔapi] may also be due to transfer from Indonesian/Malay, which has an identical word [ʔapi] 'fire'.[8]

While most vowel-initial words in Kedang derive from vowel-initial proto-forms, there are also cases where their etymological source had an initial velar fricative [h]. Illustrations are given in table 4.

Fricke (2019:119) notes that in initial position, PMP *h was most likely already lost in Proto-Flores Lembata (PFL), the ancestor of Kedang and its sister languages, Sika and Lamaholot, or earlier.[9]

There are also vowel-initial words in modern Kedang that relate to PMP forms with an initial *q, such as 'lime' and 'rain' in table 5. Fricke (2019:179) suggests that PMP *q regularly changed into glottal stop in PFL or even earlier. Subsequently, this glottal stop was lost on an irregular basis in the daughter languages.

8. Indonesian/Malay vowel-initial words regularly have a (phonetic) glottal stop onset. The variable pronunciation of [anaʔ] 'child' as [anaʔ]; or [ʔanaʔ] suggests influence from Indonesian/Malay *anak* [ʔanaʔ] ~ [ʔana]; and the loan [ˈʔimaŋ] 'imam' is borrowed from Indonesian/Malay *imam* [ˈʔimam] with an initial glottal stop.
9. Fricke (2019:119) also observes that in Kedang, a glottal stop is found sporadically in the position of initial PMP *h.

FIGURE 8. SPECTROGRAM OF ʔaʔe ame 'CHIEFTAIN' (LIT. 'ELDER.SIBLING FATHER') CONTAINING ame 'FATHER' WITHOUT AN INITIAL GLOTTAL STOP

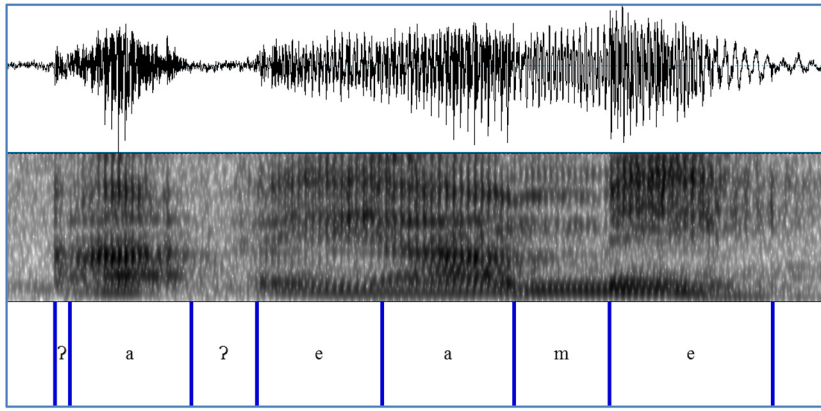


FIGURE 9. SPECTROGRAM OF ame 'FATHER' WITH AN INITIAL GLOTTAL STOP

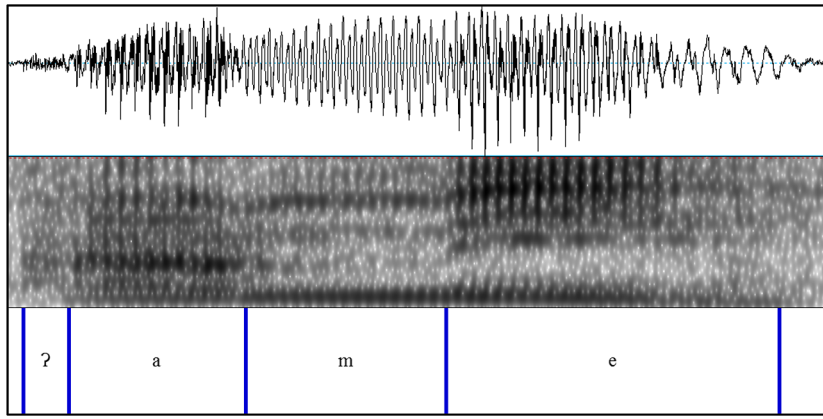


TABLE 4. KEDANG REFLEXES OF PMP FORMS WITH INITIAL *h (BLUST AND TRUSSEL 2010)

Kedang	Proto-Malayo-Polynesian	Gloss
ular	***h**ulaR	'snake'
ariʔ	***h**uaji	'younger sibling'
iʔa	***h**ikan	'fish'
api	***h**apuy	'fire'

TABLE 5. KEDANG REFLEXES OF PMP FORMS WITH INITIAL *q (BLUST AND TRUSSEL 2010; FRICKE 2019)

Kedang	Proto-Flores Lembata	Gloss
apur	*ʔapur < PMP *qapuR	'lime'
ụja†	*udan < PMP *quzan	'rain'

†Note that following IPA, [j] represents a glide.

TABLE 6. KEDANG WORDS WITH INITIAL PHONEMIC GLOTTAL STOP AND THEIR PMP ANCESTOR FORMS (BLUST AND TRUSSEL 2010; FRICKE 2019)

Kedang	Proto-Malayo-Polynesian	Gloss
ʔipeʔ	*k/gepit, *kipit	'narrow'
ʔɔ	*kahu, *ka, *huʔu	2SG
ʔai	*kahiw	'tree'
ʔutu	*kutu	'louse'
ʔapiʔ	*kapak	'wing'

In sum, there are several different sources for the words that appear to have "breathy" initial vowels. Many vowel-initial Kedang words reflect PMP forms that are also vowel-initial, but there are also some forms that result from the loss of initial *h or *q at an earlier stage. The slightly breathy nature of the Kedang initial vowels may well have a historical explanation as the remnant of these disappeared initial glottal consonants, a pronunciation that was subsequently extended to etymologically vowel-initial words, in order to enhance the phonetic distinction between these words and those with an initial glottal stop.

Regarding the initial glottal stop, many of the modern forms with initial glottal stop are related to PMP forms with an initial velar stop as Kedang underwent a regular sound change from PMP *k > *ʔ*/Ø (Fricke 2019:178).[10] Some illustrations are given in table 6.

However, our data also indicate that not all Kedang words with an initial glottal stop can be related to proto-forms with an initial /k/. What appears to have happened is that Kedang has phonemicized the glottal stop in all positions. For the initial position, this was done in analogy to the phonemic initial glottal stops that did originate from an earlier obstruent.[11]

10. The change from PMP went through a change of PFL *k > *ʔ*. Fricke (2019:178) notes that the latter change is not entirely complete in Kedang (nor in its close relatives Sika and Eastern Lamaholot), as sporadic retentions of PFL *k with the reflex *k* can be found.
11. A similar pattern of contrast between phonemic initial glottal stops and true vowel-initial words is also found in Ende, Eastern Nage, Keo, Western Ngadha, and Eastern Ngadha—all languages of Central Flores related to Kedang. See Elias (2018) for details and references.

6. CONCLUSION. As our data were not collected for the purpose of a phonetic analysis, this study is limited in terms of the amount and quality of the recorded data. However, we hope to have shown that the evidence for the breathy nature of Kedang vowels is thin.

Acoustically, we found differences between the "breathy" and "modal" vowels, but the "breathy" vowels of Kedang do not appear similar to breathy vowels described in the literature. In terms of duration, vowels in an onsetless syllable (i.e., breathy vowels) are consistently longer than vowels following a glottal or stop onset. In terms of pitch, the onsetless vowels show consistently lower f0 than those with an onset. The difference, however, disappears toward the end of the vowel in the onsetless and stop onset conditions. The amplitude difference between the first and second harmonics (H_1*–H_2*) for vowels in onsetless syllables and those in glottal and obstruent onset shows that vowels in onsetless syllables indeed have breathier quality than vowels with either glottal or stop onsets, but their higher magnitude of breathiness diminishes after the midpoint. This difference does not correspond with the typical characteristics of breathy vowels mentioned by Gordon and Ladefoged (2001): that H_1–H_2 connects with spectral tilt, and breathy voice should show a larger "fall-off" in energy than modal voice, which manifests itself in *positive* values for breathy vowels against negative vowels for modal ones. Furthermore, any observed difference disappears completely toward the end of the vowel. Conjointly, our findings raise serious doubts to the proposal that the observed differences should be attributed to phonemic vowel differences between breathy and modal.

Historically, the "breathiness" that can be perceived in words with onsetless vowels may be a remnant of earlier glottal consonants *h and *q in word-initial position that have disappeared. However, this etymology does not explain all the "breathy" sounding initial vowels, because such vowels also occur in many words that reflect *vowel*-initial PMP forms. We suggest that the "breathy" pronunciation of initial vowels probably originated as a compensation for the earlier lost glottal consonants, but was subsequently extended to etymologically vowel-initial words, in order to enhance the perceptual contrast between syllables with a phonemic glottal onset versus onsetless syllables. Regarding the etymology of the initial glottal stop, we found that many, but not all, of the modern Kedang words with an initial glottal stop derive from PMP forms with an initial velar stop. It appears that modern Kedang has phonemicized the glottal stop in all positions of the word; and for the initial position this was done in analogy to the phonemic initial glottal stops that had originated from an earlier obstruent.

To conclude, the evidence for a meaningful difference between breathy and modal vowels in Kedang is slim. Instead, we propose to describe Kedang as having just six modal vowels without any positional restrictions on the phonemic glottal stop. Taken together, our analysis makes the inventory, distribution, and etymology of segments in Kedang both simpler and more in line with its relatives in the region. The breathy-like phonation that exists in the language is

the phonetic realization of initial vowels in onsetless syllables to enhance the contrast with vowels preceded by a phonemic glottal stop. In other words, Kedang has no unique "breathy" vowels but a vowel inventory of a very common type.

APPENDIX: WORDS USED FOR THE STUDY

The Kedang words with an initial vowel or stop consonant used for this study are represented in broad IPA (i.e., the slightly breathy character of onsetless initial vowels has not been transcribed). Indonesian glosses are also provided, as these were used as prompts to elicit the Kedang data. The Indonesian words are given in standard orthography (not in IPA). For ease of reference, the words are ordered alphabetically according to their English gloss. The video and audio recordings of the entire Kedang word list (from which the words in the following list have been taken), as well as a copy of the original transcription of that list, are available at The Language Archive (TLA) https://archive.mpi.nl/islandora/search/Kedang?type=dismax.

Kedang	Indonesian	English
ɛwɔl	abu (tungku)	(fireplace) ash
ke	kami	1PL excl
ɛʔi	saya	1SG
te	kita	2PL incl
ʔɔ	kau, kamu	2SG (informal)
ˈʔite	sedikit	a few
ˈʔɔrɔʔ	menuduh	accuse
ˈʔobi	belakang	back
peˈruŋ	bambu	bamboo
ˈʔebaŋ	gudang	barn, storage house
uˈtan	kacang	bean
ˈʔele	karena	because
ue	pinang	betel nut, areca
ˈʔewaŋ	animal	binatang
kiˈtiʔ	buta	blind
ˈtuʔu	susu, buah dada	breast
ˈpɔhɔʔ	bernapas	breathe
ˈpae	bélis, emas kawin	bride price
paʔ (lumar)	bakar (kebun)	burn (garden)
ˈtɛnɛ	perahu, sampan	canoe
ˈpipin	pipi	cheek
ʔɔˈrɔʔ	dada	chest
ka ue ˈmal	makan sirih	chew betel
anaʔ	anak	child
kaˈruŋ	cakar	claw
ʔɛˈŋar	bersih	clean
paˈkejan	pakaian	clothing
taʔ	kalapa	coconut
ˈʔɛmi	dingin	cold
ˈpilir	sisir	comb
adan	datang	come
kuˈeʔ	menangis	cry
ˈʔɛbuʔ	tuli	deaf

Kedang	Indonesian	English
tɔdaʔ ˈbare	balas belis dari pihak perempuan	dowry
paˈri	jemur	dry in sun
til	telinga	ear
pulaʔ butu ˈrai	delapan belas	eighteen
purun butu ˈrai	delapan puluh	eighty
ˈela	kalejengking	ela
pulaʔ uˈdeʔ	sebelas	eleven
ˈʔame	bapak	father
uˈrun	bulu (burung)	feather
ˈʔuruŋ	kuku	fingernail
ʔaˈpi	api	fire
iʔa	ikan	fish
ɛrɛ	perangkap ikan	fish trap
ˈʔawil	mata kail	fishing hook
ˈpueʔ	jala	fishnet
puhun	bunga (di pohon)	flower (e.g., in mangga tree)
ˈʔubur	lalat	fly
tuˈen	hutan	forest
purun ˈapaʔ	empat puluh	forty
aˈpaʔ	empat	four
tepatuˈle	kodok	frog
uan	buah (umum)	fruit
pɑn	pergi	go
tuaŋˈala	Tuhan Allah	God
ʔanen	padi-padian	grain, cereal
ʔanaʔ	anak cucu	grandchild
ʔepu anaʔ abe	kakek	grandfather
ʔepu ʔarian	nenek	grandmother
taˈŋɛn	hijau	green
ˈkehe	bersalah	guilty
ʔuˈha	rambut	hair
tuˈbar	kepala	head
ˈʔutu	kutu kepala	headlice
paˈluʔ	pukul (genderang)	hit (drum)
ˈpana	panas	hot
ʔɔˈwan	lapar	hungry
ʔaˈnɛn	beras	husked rice, uncooked rice
kaˈlau	kalau	if
ˈʔimaŋ	imam	imam
kaˈwaʔ	gatal	itchy
taʔ ˈkubaŋ	ginjal	kidney
ˈtawe	ketawa	laugh
ʔaˈhaʔ	ringan	light (weight)
apur	kapur	lime
tɛˈkɛʔ	tokek	lizard
paˈko	paru-paru	lungs
pɛˈdaʔ	parang	machete
ˈpeu	mangga	mango
kuʔˈwɛʔ	perkawinan	marriage
ˈʔine	mamaˈibu	mother

Kedang	Indonesian	English
ɔˈpaʔ	lumpur	mud
ʔiˈpeʔ	sempit	narrow
puˈhɛ	pusat	navel
ʔuˈben	malam	night
pulaʔ leme ˈapaʔ	sembilan belas	nineteen
tɔn	tidak	no, not
tua ˈlahar	tua	old (person)
tuˈan	tua	old, worn
ˈtata	kakak	older sibling
ʔuˈdeʔ	satu	one
ʔɔˈrɔ	lontar palm	pohon lontar
uˈja	hujan	rain
ˈtiu	tikus	rat
puˈtuʔ	merah	red
ʔaˈnɛn	bulir padi	rice grains (unhusked, raw from field)
ʔaˈnɛn	padi (tanaman)	rice plant
taˈʔɛn	matang, (buah) masak	ripe
kaˈraŋ	kasar	rough
ˈʔɔpaŋ	bulat	round
teˈʔu	garam	salt
pɛˈju	asin	salty
tutuʔ ˈnanaŋ	berkata	say
puˈrɔʔ	kudis	scabies
taˈhiʔ	laut, air laut	sea, sea water
ʔuˈluʔ	biji	seed
pulaʔ ˈpitu	tujuh belas	seventeen
purun ˈpitu	tujuh puluh	seventy
iʔa hiu	hiu	shark
ʔiˈwiʔ	malu	shy, ashamed
teˈbeʔ	duduk	sit
ˈɛnɛŋ	enam	six
ʔaˈmaʔ	kulit	skin
ˈpiki	kurus	skinny
ʔɛˈleŋ	langit	sky
ʔuˈnan	budak, hamba	slave
ˈtɛʔɛl	tidur	sleep
ʔuˈtu	kecil	small
uˈlar	ular	snake
kiˈru	asam	sour
tutuʔ ˈnanaŋ	berbicara	speak
ˈkala	tombak	spear
ˈtamu	orang luar, orang asing	stranger
pɔˈle	pohon enau	sugar palm
ɛˈru	manis	sweet
ˈʔebɔ	ekor	tail
ˈʔodɛl	keladi	taro
ˈpulu	sepuluh	ten
ˈkapal	tebal	thick
ˈpikir	pikir	think
pulaʔ ˈtɛlu	tiga belas	thirteen

Kedang	Indonesian	English
purun ˈtɛlu	tiga puluh	thirty
telu	tiga	three
pɛˈriʔ	memotong	to cut
kiˈʔi	menggigit	to bite
ˈpuiʔ	menyiup	to blow
ˈtanɛŋ	mengubur	to bury
ʔiˈʔer	beli	to buy
pil	memilih	to choose
kɛu	naik	to climb
kaˈrɛʔ	menghitung	to count
taˈdiʔ	menebang	to cut down
ʔawe ˈwɛʔ	berkelahi	to fight
ˈkawaŋ	mengalir	to flow
ˈtawe	tumbuh	to grow
ˈʔewa	menjaga	to guard
poˈhiŋ	membantu	to help
ˈʔoni	sembunyi	to hide
paˈluʔ	pukul	to hit
paˈdɛ	membohong	to lie
ˈobaŋ	dorong	to push
pɔˈhɔʔ	menggosok	to rub
kɛu ˈtɛnɛ	berlayar	to sail
ˈkarɔ	menggaruk	to scratch
paˈnɛ	menembak	to shoot
ˈtuhuʔ	menusuk	to skewer
pɔˈtaʔ	meludah	to spit
ˈʔikuʔ	peras, remas	to squeeze
tuhuʔ	menikam	to stab
ˈpuaʔ	tinggal	to stay
kaˈkaʔ	melempar	to throw
ˈujuŋ	menikat	to tie
ɔˈkaʔ	muntah	to vomit
pɔˈhɔʔ	seka, lap	to wipe
kaˈrejaŋ	bekerja	to work
ebel	lidah	tongue
ˈʔebaŋ	rumah adat	traditional house
ʔeˈre	penyu	turtle
teˈreʔ	vagina	vagina
aˈli	urat	vein
aˈlɛn	pinggang	waist
pɑn (lala)	berjalan (kaki)	walk (on foot)
ɔˈjɔʔ	ombakˈgelombang	wave
ˈtihir	berbisik	whisper
ˈkua	mengapa	why
aˈŋin	angin	wind
ʔaˈpiʔ	sayap	wing
ʔarɛʔ ˈrian	perempuan	woman
tɛˈhɛʔ	kata	word
ˈkehe	salah	wrong
ʔuˈman	kuning	yellow
ʔɛˈwɪn	kemarin	yesterday
aˈriʔ	adik	younger sibling

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