Chapter 1

A tonological rarity: tone-driven epenthesis in Ghomala'

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This chapter focuses on a little-known tonological rarity: tone-driven vowel epenthesis. In the Cameroonian language Ghomala', an epenthetic vowel is inserted to avoid a rising tone on a syllable closed by an obstruent (e.g. /gɔ̌p/ → [gɔ̀pɔ́] 'hen'), but it is never triggered in other tonal contexts (e.g. /bɔ̂p/ → [bɔ̂p] 'thorax', *[bɔ́pɔ̀]). Morpho-phonological alternations show that when this rising tone is modified, the epenthetic vowel is also lost, illustrating strict co-variation between tone and segment. Unlike most cases of vowel epenthesis in the literature, epenthesis cannot be attributed to segmental or syllabic well-formedness. This paper catalogues all supporting evidence for tone-driven epenthesis in Ghomala', including instrumental analysis of recordings made approximately forty years apart. We show that while the motivation is quite common typologically (avoiding a contour tone on a suboptimal host), the repair itself (i.e. epenthesis) is unprecedented in the literature.

1 Introduction

What kinds of tones, tone systems, and tonological operations are common in the world's tonal languages, and which are rare? There has been considerable focus on common versus rare phenomena in non-tonal phonology – e.g. with regard to consonants (Butskhrikidze 2010; Tuttle 2010) or stress/accent (Helmbrecht 2010) – but less consideration has been given to tone.

Despite its scarce literature, certain tonological rarities are still known at this point. Languages with three to four pitch heights are common enough (e.g. low, mid, and high) but systems with five heights are rare and six virtually unattested (Yip 2002: 20; Odden 2020). Moreover, tonal operations like downstepping are

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quite common, while 'upstep' is attested but much rarer (Snider 1990). And various asymmetries have been established with respect to the frequency of anticipatory vs. regressive tone assimilation (Hyman 2007 for an extensive survey). Certain tonal patterns are rare and contentious enough to generate a literature themselves, e.g. the famous Xiamen/Southern Min tone circle within its tone sandhi system (Dong 1960; Chen 2000: 42ff; Zhang et al. 2006; *inter alia*).

For this chapter, our specific focus is on rarities in tone/segment interaction. Some interactions well-known and quite common such as consonant depression by voiced consonants are, while others are exceedingly rare such as cases when the tone height/type is dependent on vowel height (Jiang-King 1999; Yip 2002: 31). In general, most interactions happen in the direction from segments to tone, and rarely from tone to segments (Wee 2019: 208). What we show here is an even rarer case: the insertion of a vowel itself in order to host tone, i.e. a 'tone-driven epenthesis'. While little attention has been given to the possibility of tone-driven epenthesis, we demonstrate its existence in the Cameroonian language Ghomala' based on a variety of arguments from both root structure and morphophonological alternations.

This paper is organized as follows. Section 2 provides essential background information on the Ghomala' language, and Section 3 presents the evidence for tone-driven epenthesis Following these, Section 4 situates the rarity of tone-driven epenthesis in a typological perspective, and Section 5 concludes this chapter.

2 Background on Ghomala'

2.1 The language setting

Ghomala' (pronounced [ɣɔ̀málá?], ISO 639-3: `bbj`) is a Bamileke language of the Grassfields family spoken in Western Cameroon, part of the larger Bantoid subgroup within the Niger-Congo phylum. In this paper, we examine data from the Bandjoun and Baham varieties. These are closely-related varieties of the Central dialect of Ghomala' (Domche-Teko & Hatfield 1991: 3; Mba 1997), as opposed to the North and South dialects. In fact, Ghomala' has been called simply Bandjoun in the literature (a.k.a. Banjun or simply Jo), so-named because it is the main Ghomala-speaking *chefferie* (Mba 1997: 77).

Ghomala' has at least 350,000 speakers (Kamdem 2020: 2, citing Simons & Fennig 2018). Its speaker community is likely much higher than that. For example, religious organizations like the Joshua Project claim 1.145 million speak-

ers[1]. Ghomala' is relatively healthy, widely spoken as the community language (Domche-Teko & Hatfield 1991), with most of the children being at least Ghomala'-French bilingual today (Kamdem 2020: 3, fn4). Ghomala' (especially of Bandjoun, the *de facto* standard) is often used in print, taught in local schools, and used regularly on local radio. There have been various literacy and standardisation efforts underway for several decades now (Domche-Teko & Hatfield 1991: 8). Domche-Teko & Hatfield (as well as Bomda 2005: 45ff.) provide a comprehensive timeline of the earliest descriptions of Ghomala', dating back to the colonial period.

Data in this chapter come primarily from the grammatical description in Nissim (1972; 1981) and recordings made around the time of these publications, as well as from a modern dictionary of Ghomala' (Eichholzer 2010). The data relevant to tone-driven epenthesis are also confirmed by other publications on Ghomala' (Ntagne & Sop 1975; Piron 1997), as well as YouTube recordings made by Ghomala' language advocates (these play a role in Section 3.3). These latter recordings are made some forty years after Nissim's, thereby demonstrating the stability of these Ghomala' epenthesis patterns.

2.2 Phonological profile

Ghomala' has a rich set of consonantal and vocalic contrasts (Nissim 1981; Bomda 2005), summarized in Table 1. Among consonants, there are five places of articulation: stops, affricates, fricatives, nasals, and approximants. The consonants in parentheses may be derived from the other consonants at an abstract level of analysis Nissim (1981: 121–130), but for practical purposes they are transcribed as separate units. Among vowels, there are four heights and three degrees of backness.

Table 1: Segmental inventory of Ghomala'

LABIAL		DENTAL		PALATAL		VELAR		GLOTTAL	FRONT	CENTRAL	BACK
p	b	t	d			k	g	ʔ	i	ʉ	u
pf	bv	ts	dz	c	j				e	ə	o
f	(v)	s		(š)	(ž)	(γ)		h	ɛ	α	ɔ
m		n				ŋ				a	
		(l)		y		ʉ̂					
				ẅ		w					

Ghomala' transcriptions follow the IPA except for c=[tʃ] and j=[dʒ] (Nissim actually describes them as both palatal and affricated), š=[ʃ], ž=[ʒ], y=[j], ẅ=[ɥ], ᶣ=[ɥ], ᵾ=[ʉ]~[ɯ], and α=[ɐ]. See [Nissim (1981](#): 45-71) for phonetic details. Some marginal phones not included in this table are [z] and a series of aspirated stops [tʰ dʰ pʰ bʰ kʰ], as well as various nasal+stop sequences and consonant+glide sequences.

Two final phonological details are relevant for our later discussion. First, only the consonants /m ŋ p k ʔ/ may appear in coda position. Second, both lexical morphemes (i.e. roots) and functional morphemes are prototypically monosyllabic. This fact is important for our analysis of final epenthetic vowels, which expand a monosyllabic form into a disyllabic one.

2.3 Morphological and syntactic profile

Ghomala' nouns belong to one of six noun classes (three singular and three plural). Noun classification is often only reflected in noun phrase concord rather than through marking on the noun itself (e.g. the demonstrative 'this' has forms *yaŋ*, *tsɔ*, *pɔ*, and *mɔ*, depending on the class of the noun).

Canonical word order is [SUBJECT PARTICLE(S) VERB OBJECT (OTHER)] (where 'other' includes *inter alia* adverbs or prepositional phrases). A typical sentence structure is illustrated in (1). We will explain the tone marks shortly.

(1) [gā ê də̄ má ǎ gɔ̄ m̄ lɔ́ʔtà]
     gā ê   N-lə̄   má ǎ   N-ɣɔ̄   m̄ lɔ́ʔtà
     1S H_PST INFL-take mother my INFL-go to hospital
     'I took my mother and went to the hospital (today)' ([Kamdem 2020](#): 100)

Verbal affixation is highly limited, and inflection is primarily marked via a series of pre-verbal particles ([Kamdem 2020](#): 97–98), such as *ê* H_PST (hodiernal past) in (1). Several inflectional patterns contain a general inflectional prefix *N-* INFL (also seen in 1), which is realized phonetically either as pre-nasalization or some other consonantal change. Suffixation is restricted to a small set of multi-functional derivational markers indicating meanings such as repetition of action, plurality on arguments, valency changes, *inter alia* ([Mba 1997](#)). These facts will become important as we develop our arguments in Section [3](#).

2.4 Tone system

At a basic level of analysis, Ghomala' makes a central distinction between high (H) and low (L) tone. In reality, there are numerous surface tone heights and

several contour tones as well. To illustrate the tone system, consider monosyllabic roots with open syllables in Table 2. Here, a six-way tone contrast can be discerned, based on the pronunciations of nouns in isolation compared to their pronunciations when they appear in object position after a verb.

This table shows that there are two types of high tones. One is consistently realized as high, and transcribed simply as H (row a). The other is realized as high in isolation but as a downstepped high in object environment, transcribed ꜝH (b). Likewise, there are two types of low tones. One is realized as a level low tone which does not fall to the lowest part of the pitch range (c), and is transcribed as L° with a degree symbol (following Africanist conventions – e.g. Bird 1999). The other low tone is one which *does* fall to the lowest part of the pitch range (d), and is transcribed simply as L. Finally, there are two contour tones. One is a LH tone which is realized as rising in isolation but may also be realized as a downstepped high in certain contexts (e). The other is a HL tone, consistently realized as a falling tone. Note that the tone numbers provided are schematic approximations of pitch height (where 1 is the lowest and 5 the highest).

Table 2: Six-way tone contrast (Nissim 1981: 150, 153)

	Tone	Isolation			Context		
a.	H	**fɑ́**	⌐	'parent'	ŏ ꜝyɔ́ **fɑ́**	⌐	'you saw the parent'
b.	ꜝH	**dhɔ́**	⌐	'spouse'	ŏ ꜝyɔ́ **ꜝdhɔ́**	⌐	'you saw the spouse'
c.	L°	**tsɔ̀°**	⊣	'cola nut'	ŏ ꜝyɔ́ **tsɔ̀°**	⊣	'you saw the cola nut'
d.	L	**tà**	⌐	'pot'	ŏ ꜝyɔ́ **tà**	⌐	'you saw the pot'
e.	LH	**bvʉ̌**	⌐	'dog'	ŏ ꜝyɔ́ **ꜝbvʉ́**	⌐	'you saw the dog'
f.	HL	**bʉɔ̂**	⟍	'madman'	ŏ ꜝyɔ́ **bʉɔ̂**	⟍	'you saw the madman'

Regarding the level low tone (row c), several sources on Ghomala' transcribe it simply as a mid tone (Bomda 2005; Bessala & Moguo 2017; Kamdem 2020; Moguo 2021). Nissim (1981: 72) refers to it as *le ton central* which is typographically indicated by the lack of a diacritic, and explicitly contrasts this tone against a mid tone (*ton moyen*) found in related languages but not Ghomala' (we refer the interested reader to Nissim for the exact arguments). In this work, we shall exclusively use the L° convention. At a descriptive level, all the aforementioned variants are acceptable, demonstrated in Table 3. This additionally shows the uniformity across all sources in marking high and low tone.

Table 3: Notational equivalence of L°, unmarked, and M across sources

	Tone	This work	Nissim 1981		Bomda 2005		Meaning
a.	H	só	só	(p. 72)	só	(p. 56)	'friend'
b.	L°	bàp°	bap	(p. 50)	bāp	(p. 53)	'meat'
c.	L	fò	fò	(p. 50)	fò	(p. 51)	'chief'

3 Tone-driven epenthesis in Ghomala'

Out of this six-way tone contrast, the most important for this chapter is the rising tone (LH, row e from Table 2). Building on the original description of Nissim (1981), we defend the thesis that this tone (and this tone alone) conditions tone-driven epenthesis, defined as the phonological insertion of a vowel in order to realize a pitch target. Specifically, words like /gɔ̌p/ 'chicken' are realized as [gɔ̀pə́] where the final [ə] is epenthetic.

3.1 Segment-tone co-variation

The first thing to establish is co-variation between a final vowel segment and a rising tone. In Table 2, we showed the contrastive tone patterns on monosyllabic roots with open syllables. These same patterns are found on syllables closed with a sonorant coda /m ŋ/ (the only sonorants allowed in this position), demonstrated in Table 4. Note that the distinction between lexically contrastive H and downstepped ꜝH is not always apparent (e.g. in dictionary entries), since they are pronounced identically in isolation. We, therefore, do not make this distinction in this table, nor in the tables which follow. Our analysis of epenthesis is not affected by this.

Table 4: Tones on syllables with sonorant codas

	Tone	Example		Meaning	Source
a.	H	/kɔ́ m/	[kɔ́ m]	'crab'	(Nissim 1981: 216)
b.	L°	/là m°/	[là m°]	'condiment'	(Nissim 1981: 72)
c.	L	/là m/	[là m]	'dry season'	(Nissim 1981: 72)
d.	HL	/fâm/	[fâm]	'plantation'	(Eichholzer 2010: 16; < *farm*)
e.	LH	/bə̌m/	[bə̌m]	'destiny'	(Nissim 1981: 74)

Let us next consider syllables closed by an obstruent coda, which in Ghomala' are only /p k ʔ/. Data are given in Table 5. A LH-toned syllable (row e) may be realized either as a monosyllable with a rising tone (faithful to the underlying representation) or a disyllable with a vowel epenthesized to the root. In this latter variant, the L portion of the tone falls on the lexical vowel and the H portion on the epenthetic vowel. Importantly, epenthesis is never found in other tonal contexts.

Table 5: Tones on syllables with obstruent codas

	Tone	Example		Meaning	Source
a.	H	/káp/	[káp]	'pipe'	(Eichholzer 2010: 23)
b.	L°	/bàp°/	[bàp°]	'animal'	(Eichholzer 2010: 3)
c.	L	/pàp/	[pàp]	'wing'	(Nissim 1981: 218)
d.	HL	/lâp/	[lâp]	'elegance'	(Eichholzer 2010: 31)
e.	LH	/lǎp/	[lǎp]~[làpə́]	'pool of water'	(Eichholzer 2010: 31)

The two pronunciations in row e. are found throughout the Ghomala' literature for LH words in isolation. Often the same word is transcribed in both ways across sources. For example, what (Nissim 1981: 198) transcribes as [vɔ̀pə́] 'dust', Moguo (2021: 141) transcribes as [vǒp]. Forms with and without the final vowel are thus interchangeable, and there is no contrast between such forms.

In the most comprehensive description of Ghomala' to date, Nissim (1981) is explicit in treating this final vowel as epenthetic, stating that its only function is to support the tonal complex (pp. 65, 90). All cases of words with obstruent codas show the epenthetic vowel variant if and *only* if it has rising tone. The example set in Table 6 demonstrates epenthesis with the three possible obstruent codas /p k ʔ/. With coda /p/ and /k/, an epenthetic [ə] is inserted to host the H portion of the rising tone, while with /ʔ/ it is either [ə] or a copy of the root vowel (depending on the vowel quality).

As stated, there is no comparable variation for other types of tone. Considering forms in Table 5, there exists no variation for /pàp/ 'wing' between [pàp] and *[pàpə̀], or for /lâp/ 'elegance' between [lâp] and *[lápə̀], *et cetera*. This fact demonstrates that epenthesis of a final vowel is not triggered by a markedness constraint against final obstruent codas. If the latter were the case, we would expect epenthesis to be conditioned by the segmental context regardless of the tonal context.

Recordings of Ghomala' words and phrases pronounced in isolation confirm

Table 6: Epenthesis when rising tone appears with obstruent coda

	Example		Meaning	Source
a.	/gǒp/	[gɔ̀pə́]	'hen'	(Nissim 1981: 63)
	/cǎp/	[càpə́]	'corn cake'	(Nissim 1981: 74)
b.	/fɔ̌k/	[fɔ̀χə́][a]	'cold'	(Nissim 1981: 65)
	/sǎk/	[sàχə́]	'wall'	(Nissim 1981: 65)
c.	/gwɔ̌ʔ/	[gwɔ̀ʔə́]	'termite'	(Nissim 1981: 146)
	/lǎʔ/	[làʔá]	'village'	(Nissim 1981: 74)
	/pǔʔ/	[pùʔú]	'package'	(Nissim 1981: 146)
	/gǔʔ/	[gʉ̀ʔʉ́]	'strength'	(Nissim 1981: 90)

[a]There is an independent process of frication (and backing) which affects /k/ between vowels.

the variability between the presence or absence of a final vowel. These recordings were provided by Larry Hyman, and were originally recorded under the direction of Gabriel M. Nissim in Cameroon around the time of his writing Nissim (1981). The recordings reflect the speech of a single male speaker of Ghomala' saying individual words in isolation and within associative (i.e. genitive) noun phrases containing two nouns [N$_1$ N$_2$], in either N$_1$ or N$_2$ position (we describe these constructions in Section 3.3).

Figures 1 and 2 show roots with LH tones (the pitch is the red line, and the pitch range is marked at the right). Figure 1 shows a LH tone on an open syllable with a clear and steady rise, while Figure 2 shows a LH tone on a word with a coda /p/. It is clear from the spectrogram that in this latter context a full vowel [ə] appears after the final consonant and bears the H portion of the tone.[2]

Compare this to Figure 3 which shows a level low tone (L°) on a syllable closed by the obstruent /p/. Unlike Figure 2, here the /p/ is unreleased and no vowel follows it. Moreover, unlike the coda obstruents the coda nasals /m ŋ/ never show variants with an epenthetic vowel. A spectrogram confirms the lack of a final vowel in such LH contexts, shown in Figure 4. It is clear that the rising portion of the pitch is realized on [ŋ] itself. These patterns show that the sonorant codas

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[2]As a reviewer points out, the initial nasal bears pitch as well, which calls into question the actual number of syllables in these figures. We interpret this initial nasal as forming a single syllable with what follows (at least in the phonology), and its low pitch as due to phonetic interpolation. Regardless, the syllabicity of this nasal is orthogonal to our main point with respect to tone-driven epenthesis.

L		LH
m	jw	i
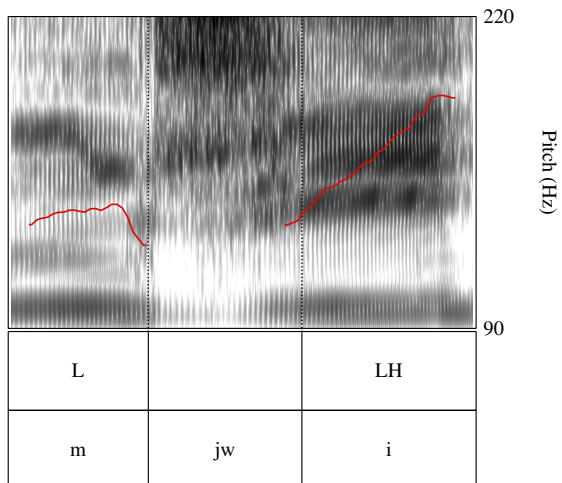
Figure 1: LH tone on open syllable – /mjwǐ/ [mjwǐ] 'woman' (spoken in isolation)

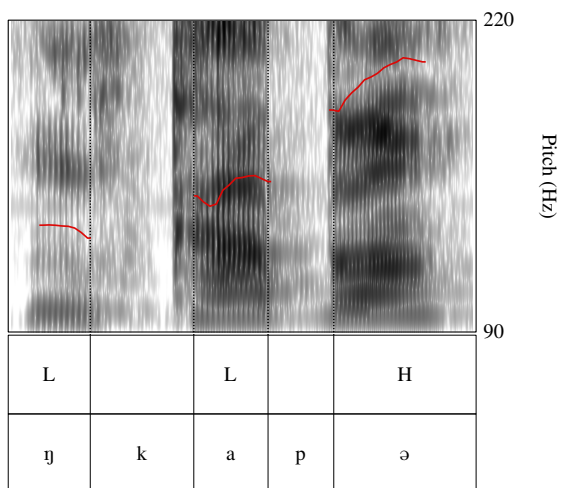| L		L		H
ŋ	k	a	p	ə

Figure 2: LH tone on syllable with coda /p/ – /ŋkǎp/ [ŋkàpə́] 'money' (spoken in isolation)

behave similarly to open syllables in permitting a rising tone realization without recourse to epenthesis.
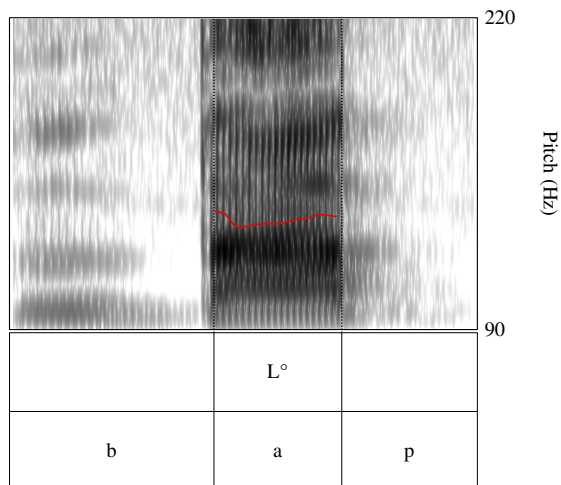

Figure 3: L° tone on syllable with coda /p/ – /bàp°/ 'animal' (spoken in isolation)

3.2 Against a deletion alternative

We now defend our analysis that this is indeed epenthesis, as opposed to an alternative hypothesis which would involve the deletion of an underlying final vowel, i.e. /cvc/ → [cvcə], rather than /cvcə/ → [cvc].

The first argument involves general root phonotactics. As stated, the vast majority of roots in the language are monosyllabic (e.g. CV/CVC shapes). The major exception to this generalization are exactly those [cv̀cə́] forms detailed above. If we treat these as underlyingly /cv̌c/ which only become disyllabic later in the derivation, this unifies the possible shape of roots.

Multisyllabic words which are not attributable to this epenthetic operation are nearly always decomposable into multiple morphemes. These include compounds of some type (e.g. *nɔ̀m-gẅì* 'panther', more literally 'animal-panther') or derived forms with a derivational affix (e.g. suffixes /-nyə/ and /-tə/ or the prefix /kɜ̀-/). Examples of the latter are given in (2). Disyllabic sequences with final [ə]
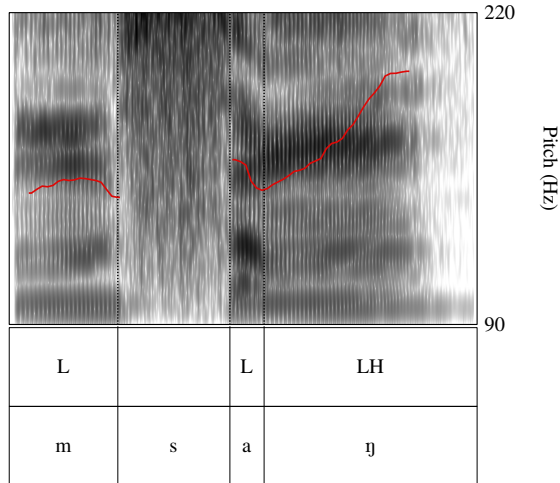
Figure 4: LH tone with sonorant coda – /msǎŋ/ [msàŋ́] 'birds' (spoken in isolation)

are in fact quite common in morphologically complex words, demonstrating that there is no general phonological constraint against final [ə] in Ghomala'.

(2) Disyllabic stems as multi-morphemic (Nissim 1981: 91-92)

    a. kùŋ-nyə̀
       love-RECIP
       'love each other'

    b. pà-tə̀
       carry.on.back-with.care
       'carry carefully' (e.g. of a baby)

    c. kə̀-lóʔ
       DEPR-?
       'badly put together'

Any remaining forms which cannot be decomposed into multiple morphemes constitute a marginal percentage of the lexicon, e.g. /bìyɛ́/ 'peanut', /gə̀fɑ̀/ 'corn', /kə́pák/ 'lizard', among others. To this we can add loanwords from English and French found in Eichholzer (2010), e.g. /bə̀lə̀ŋ/ from English 'blanket' or /bàtô/ 'boat' from French *bateau*.

The second argument for an analysis as epenthesis over one as deletion involves a restriction on the distribution of vowel quality. Recall the vowel inventory /i e ɛ ʉ ə ɑ a u o ɔ/ of Ghomala' presented in Table 1 (where α is IPA [ɐ]). Of these, not all are permitted in closed syllables. Before coda /p/ and /k/, only the low vowels /ɔ/ and /a/ are allowed (a few loanwords escape this generalization, e.g. /hêp/ 'help' – Eichholzer 2010: 21). The data shown from Table 6 above are representative of this restriction.

From a diachronic perspective, it is clear that multiple vowel categories have merged in these closed syllable contexts. Comparing Ghomala' data to Proto-Eastern Grassfields (Proto-EG) reconstructions (Elias et al. 1984), we see widespread neutralization before coda obstruents, such as before Proto-EG *b and *p codas shown in Table 7. Such data show that each of these distinct vowels in Proto-EG corresponds to a Ghomala' form with /ɔ/.

Table 7: Historical merger of vowel qualities before obstruent codas

Proto-EG (Elias et al. 1984)[a]				Ghomala'		Source
*-gúɓ	*chicken	(p. 52)	>	gɔ̌p~gɔ̀pə́	'hen'	(Eichholzer 2010: 18)
*-kíɓ	*fingernail	(p. 90)	>	ŋkɔ̀pə́	'nail'	(Nissim 1981: 198)
*-bóp-	*fear	(p. 90)	>	pwɔ́k	'afraid'	(Nissim 1972: 43)
*-béɓ	*he-goat	(p. 59)	>	pɔ̌p~pɔ̀pə́	'goat'	(Eichholzer 2010: 45)

[a]The tone marks above the consonants in these proto-forms are reconstructed floating tones. We repeat the transcription as found in the source.

Importantly, this constraint holds both for [cvκ] forms with a surface obstruent coda (e.g. [bàp°] 'animal'), as well as [cvκə] forms with a surface [ə] (e.g. [gàpə́] 'antelope'). If the latter forms were underlyingly /cvcə/ then we would have expected a wider range of vowels to be permitted, since the environment for the first vowel would not be a closed syllable on the surface. In short, we would expect non-existent native roots such as /bùpə́/ and /gèkə́/. Treating all such forms as underlying /cvc/ succinctly accounts for why such forms do not exist.

3.3 Morpho-phonological alternations

As further support for our analysis as epenthesis, Ghomala' shows regular morpho-phonological alternations between surface forms with and without a final [ə].

This demonstrates that tone-driven epenthesis is an active part of Ghomala' grammar.

Let us first consider data from derivation which show the parity between monosyllables and disyllables with final [ə] in the realization of LH tone. In one type of deverbal nominalization, the lexical tone of the root is overwritten with LH tone, shown in Table 8. (Note that verb roots have only a H vs. L distinction – see Section 3.4 below). With open syllables (row a) or syllables with coda sonorants (b), the pattern surfaces with a rising tone on a monosyllable without complication. In contrast, the LH pattern induces an epenthetic [ə] in syllables with coda obstruents (c), mirroring the distribution of underived roots in the lexicon.

Table 8: [ə] alternations in V→N derivation (Nissim 1981: 288-289)

a.	tɯɔ̀	'be strong'	→	tɯɔ̌	'iron'
	sú	'(to) weed'	→	sǔ	'hoe'
b.	tùŋ	'dig inside'	→	ntŭŋ	'throat'
	tɔ́m	'push'	→	tɔ̌m	'fruit'
c.	tsɯ̀ʔ	'twist'	→	dzɯ̀ʔɯ́	'liana (vine)'
	fɔ́k	'blow (cold)'	→	fɔ̀kɔ́	'cold'

Next, consider [ə] alternations in noun phrases, specifically in the associative construction. To understand these data, first let us establish the relevant parts of this construction. Associative constructions are used to express possession and compounding, and involve two nouns where the first noun is the head and the second noun is the modifier. We exemplify it in Table 9, involving various H- and L-toned nouns in N_1 position and the noun /bàp°/ 'animal' in the modifier position N_2.

Table 9: Class-dependent grammatical tone (Nissim 1981: 249-250)

	Class	N_1		N_2		Output	Meaning
a.	CL1	/mú	Ⓛ	bàp°/	→	[mû bàp°]	'the child of the animal'
		/gì	Ⓛ	bàp°/	→	[gì bàp°]	'the voice of the animal'
b.	CL3	/thɔ́	Ⓗ	bàp°/	→	[thɔ́ bàp°]	'the head of the animal'
		/kwɔ̀	Ⓗ	bàp°/	→	[kwɔ̀ ꜝbàp°]	'the foot of the animal'

Notice that there are two classes indicated here, class 1 (CL1, in row a) and class 3 (CL3, in b). As is typical for related Bantu/Bantoid languages, Ghomala' has an elaborate noun class system which is reflected morphologically in the shape of morphemes that are in agreement with the head noun. In the associative construction, noun class is reflected by distinct grammatical tones. Class 1 nouns condition a floating low grammatical tone (Ⓛ) which links the two nouns (following Yip 2002, floating tones unassociated in the input are circled). In contrast, other classes (e.g. class 3) condition a floating high tone (Ⓗ). These grammatical tones result in various tonal changes, e.g. in row a. /mú/ becomes falling [mû], while in row b. the second low tone becomes a downstepped low tone.

Nissim (1981) provides extensive paradigms of associative constructions. We schematize the relevant tonal patterns of these paradigms in Tables 10 and 11. The underlying tones of the first noun (the head noun, N_1) are listed in the first column, and the underlying tones of the second noun (the modifier, N_2) are listed in the top row. Table 10 shows the tone paradigm for associative constructions involving a class 1 head noun (e.g. /mú/ 'child' from Table 9). Such environments condition the floating Ⓛ grammatical tone between N_1 and N_2. Here, the tone of N_2 remains intact while the tone of N_1 is altered. In contrast, Table 11 summarizes those constructions involving a class 3 head noun (e.g. /thɔ́/ 'head'). These condition the floating Ⓗ grammatical tone between N_1 and N_2. Here, it is the tones of N_2 that are modified, while those of N_1 remaining largely unmodified.

Table 10: Associative tone paradigm with CL1 noun in N_1, conditioning floating Ⓛ

N_1 / N_2	H		ꜜH		L°		L		**LH**	
H	[HL	H]	[HL	H]	[HL	L°]	[HL	L]	**[HL**	**LH]**
L°	[HL	H]	[HL	H]	[HL	L°]	[HL	L]	**[HL**	**LH]**
L	[L	H]	[L	H]	[L	L°]	[L	L]	**[L**	**LH]**
LH	[HL	H]	[HL	H]	[HL	L°]	[HL	L]	**[HL**	**LH]**

For our examination of tone-driven epenthesis, the relevant portions of both these tables are the rightmost columns (in bold). For nouns in N_2 position with an underlying LH pattern, there are two surface realizations depending on the noun class of N_1. If a class 1 noun is in N_1 position (Table 10), N_2 surfaces with a rising tone. In contrast, if the noun of N_1 is class 3 (Table 11), N_2 surfaces with a downstepped high tone.[3]

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[3]Notice in Table 11 that the high tone of N_2 is not downstepped after a low tone. There is no

Table 11: Associative tone paradigm with CL3 noun in N_1, conditioning floating ⊕

N_1 / N_2	H		ꜜH		L°		L		**LH**	
H	[H	H]	[H	ꜜH]	[H	L°]	[H	L]	**[H**	**ꜜH]**
L°	[L	H]	[L	H]	[L	ꜜL°]	[L	ꜜL]	**[L**	**H]**
L	[L	H]	[L	H]	[L	ꜜL°]	[L	ꜜL]	**[L**	**H]**
LH	[LH	H]	[LH	ꜜH]	[LH	L°]	[LH	L]	**[LH**	**ꜜH]**

This [LH]~[ꜜH] alternation surfaces as a purely tonal phenomenon in open syllables and in syllables with coda sonorants, e.g. /bvǔ/ [bvǔ] ~ [ꜜbvú] 'dog' in (3).

(3)   [LH]~[ꜜH] morpho-phonological alternation in N_2

    a.   /mú ① bvǔ/ → [mû bvǔ] 'the child of the dog' (Nissim 1981: 264)

    b.   /thə́ ⊕ bvǔ/ → [thə́ ꜜbvú] 'the head of the dog' (Nissim 1981: 153)

Importantly, when there is a coda obstruent N_2 nouns show the expected co-variation between tonal pattern and the presence of a final epenthetic vowel. Consider the noun /gɔ̌p/ 'hen' which in isolation is pronounced [gɔ̀pə́]. Nissim (1981: 157-158, 250-252) provides the paradigms in Table 12 which show that in the surface [LH] context this surfaces as [gɔ̀pə́] with a final vowel (a), but in the surface [ꜜH] context it surfaces as [ꜜgóp] without the final schwa (b).

Table 12: Co-variation between tone pattern and the presence of a final [ə] in morpho-phonological alternations (Nissim 1981: 157-158, 250-252)

a.	/mú	①	gɔ̌p/	→	[mû	gɔ̀pə́]	'the child of the hen'
	/kòʔ°	①	gɔ̌p/	→	[kôʔ	gɔ̀pə́]	'the rooster of the hen'
	/gì	①	gɔ̌p/	→	[gì	gɔ̀pə́]	'the voice of the hen'
	/dyə̌	①	gɔ̌p/	→	[dyə̂	gɔ̀pə́]	'the house of the hen'
b.	/thə́	⊕	gɔ̌p/	→	[thə́	ꜜgóp]	'the head of the hen'
	/mkòʔ°	⊕	gɔ̌p/	→	[mkòʔ	góp]	'the roosters of the hen'
	/kwə̀	⊕	gɔ̌p/	→	[kwə̀	góp]	'the foot of the hen'
	/tǎŋ	⊕	gɔ̌p/	→	[tǎŋ	ꜜgóp]	'the ear of the hen'

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contrast between [H] and [ꜜH] in this environment.

Recordings made by Ghomala' language advocates and teachers confirm this distribution in morpho-phonological alternations. Consider the following recording publicly available on YouTube, titled *Animaux en ghomala.*[4] The speaker speaks in the Baham variety, which is part of the central Ghomala' dialect very closely related and geographically proximate to Bandjoun. The recording includes individual names of common domesticated and wild animals within the Ghomala' environs, and contains several simple nouns and noun phrases in isolation.

In this recording, open syllables or syllables with sonorant codas with rising tones surface as expected, e.g. [tsǎ] 'elephant' (at 9'33" in the video) and [bàpdǎm] 'rat' (3'15"). There are also 28 instances of a root with an obstruent coda, and all 28 comply with the expected patterns of epenthesis. Representative examples are in Table 13, which provides a sample of words with coda consonants of all tone patterns. Each word in this table is accompanied by its corresponding entry in the Ghomala' dictionary (Eichholzer 2010). If the obstruent coda occurs with H, HL, L°, or L tone, then the form ends with a consonant. However, if it occurs with a LH tone (e.g. [sǔ pɔ̀bɔ́] 'castrated goat'), then the word ends in an epenthetic vowel (row e).

Table 13: Corroborating evidence for tone-driven vowel epenthesis from the *Animaux en ghomala* video (Baham variety of Central dialect)

	Tone	Example		Location	Cf. Eichholzer (2010)
a.	H	[nɔ́k]	'snake'	(13'31")	[nɔ́k] 'snake'
b.	HL	[dzɔ̂p]	'hedgehog'	(16'20")	[dzɔ̂p] 'hedgehog'
c.	L°	[ŋgàp°]	'antelope'	(11'12")	[gàp°] 'antelope'
d.	L	[kwàk]	'jigger flea'	(32'02")	[kwàk] 'jigger'
e.	LH	[sǔ pɔ̀bɔ́]	'castrated goat'	(6'51")	[sǔ] 'castrate' & [pɔ̌p]~[pɔ̀pɔ́] 'he-goat'

Figure 5 shows that the root /gǎp/ 'chicken' is realized in this video as [gɔ́p] with a high tone and no final epenthesis when spoken in isolation.[5] Although this pronunciation of a rising tone as high in isolation is different from the data from

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[4]This is available at https://www.youtube.com/watch?v=M5S1Pmw4ND8, by speaker Kamdem Wambo. Numerous other Ghomala' language YouTube recordings exist, which we do not analyze in this paper.

[5]Faint aspiration can be detected in the recording, on this and many other obstruent-final tokens. Due to noise in the recording however, it is more difficult to clearly see on the spectrogram. The indeterminacy of aspiration is notated as '(h)' in Figure 5.

the Bandjoun variety (cf. Tables 5 and 7), it still supports our main thesis since there remains strict co-variation between tone and epenthesis. This is confirmed by Figure 6 of the noun phrase [mɨ̀ gɔ̀bə́] 'chick' (lit. 'baby chicken'). Here, the final noun is realized as [LH], with the low portion hosted on the lexical vowel and the high portion on an epenthetic vowel [ə], as expected.
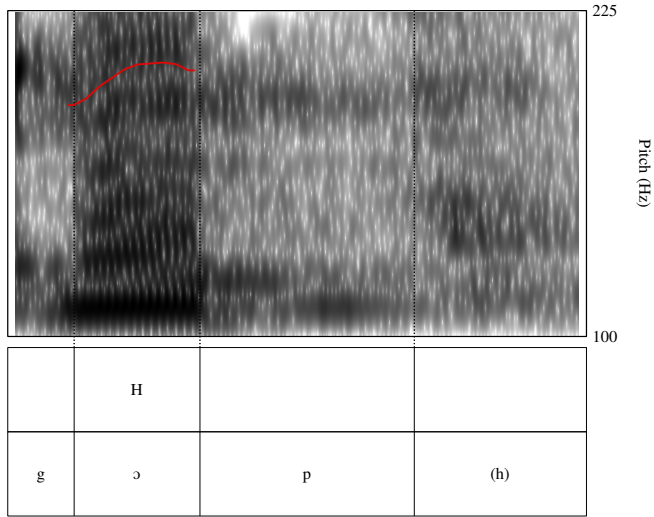

Figure 5: H tone without epenthesis – [gɔ́p] 'chicken' spoken in isolation (24′28″)

3.4 Indeterminate data from verb inflection

To wrap up our discussion of tone-driven epenthesis in Ghomala', we provide a final note on a set of indeterminate data from verb inflection. Unlike nouns, Ghomala' verb roots have only a basic underlying H vs. L distinction (Nissim 1972: 79; Mba 1997: 78), a property the language shares with other Bamileke languages (Elias et al. 1984: 62). Parts of the verbal system confirm the observations made for the nominal domain, e.g. for L-toned roots the imperative is expressed with LH tone realized as a rising tone on roots like [pàá] 'carry on the back!' but with an epenthetic [ə] on roots like [càpə́] 'insult!' (Nissim 1972: 80). However, other parts of the system complicate our generalizations.

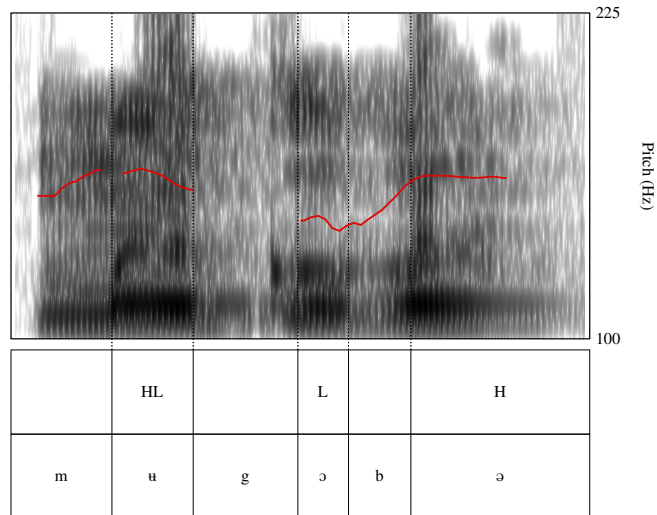Consider the data in (4) from Bessala & Moguo (2017) involving the lexically

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Figure 6: LH tone *with* epenthesis –[mʉ̂ gɔ̀bɔ́] 'chick' (25'10")

low-toned verb /ʒwɔ̀p/ 'dance' (in bold in the example). Here, too, there is an alternation between an obstruent coda and a final [ə]. Note that this source transcribes the level low tone (i.e. L°) as a mid tone, which we repeat.[6]

(4) a. bə́jə̄ pō **ʒwɔ̄p** áá, bə̄   gâ nə̄ŋ
         COND you **sing** DEF COND I   dance
         'If you sing then I will dance' (Bessala & Moguo 2017: 153)

    b. tâmō bə̄ wə̄ **dʒwɔ́pə́**
         Tamo COP PROG **sing**
         'Tamo is singing' (Bessala & Moguo 2017: 151)

While the form in (a) without epenthesis complies with our analysis, the form in (b) is unexpected, since it shows a final [ə] not co-occurring with a LH tone. We cannot attribute the presence of [ə] here to the avoidance of a rising tone on a syllable closed by an obstruent.

The presence of this inflectional 'final vowel' has been noticed already in the literature on Ghomala' (Bessala & Moguo 2017; Kamdem 2020: 100), but at this

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[6]There are other orthogonal changes as well, such as changes to the initial consonant of the verb. These are not relevant to our discussion.

point its function and distribution are not yet established. To complicate things further, variability is common even within the same inflectional context. For example, one context where this final vowel appears is with lexically low-toned roots in the infinitive, e.g. /càp/ 'insult' surfaces as [šápə̀°] 'to insult' (Nissim 1972: 77). While Nissim more or less consistently transcribes final vowels in such infinitival contexts, in sources such as Mba (1997) (of the same Bandjoun dialect) there is no indication of such vowels in equivalent contexts. This is exemplified in Table 14. No final vowel appears in either source with roots of the H tone class (row a), but the sources differ as to whether another vowel is added with roots of the L tone class (b). (Notice as well that Mba indicates infinitives with an initial prefix *nə́-*, while Nissim often has initial consonant changes in infinitive context.)

Table 14: Variation for infinitive forms across sources

	Tone class		INF (Nissim 1972)	INF (Mba 1997)	Meaning
a.	H	fíʔ	[fîʔ°]	[nə́-fîʔ]	'to descend'
		sɛ́	[sɛ̀°]	[nə́-sɛ̂]	'to count'
b.	L	fìʔ	[fíʔì°]	[nə́-fìʔ]	'to water'
		vɔ̀k	[bvɔ́χə̀°]	[nə́-vɔ̀k]	'to live (on)'
		pà	[báà°]	[nə́-pà]	'to carry on back'

In total, while tonal-driven epenthesis can be firmly established for nouns, the situation with verbs requires further data and analysis.

4 Tone-driven epenthesis in a typological perspective

In the previous section, we have shown that Ghomala' disprefers a rising tone on a syllable closed by an obstruent. We can call this the *[čʁ] constraint. To avoid such a structure, a final vowel is epenthesized which hosts the high tone portion of the contour (i.e. a word /gǒp/ becomes [gòpə́] 'hen'). Evidence came from root phonotactics as well as morpho-phonological alternations, showing that this is an active part of the Ghomala' phonological grammar.

In this section, we situate the Ghomala' *[čʁ] constraint and tone-driven epenthesis in a cross-linguistic perspective, with comparison to similar types of patterns in various languages. We divide this section into three parts. In Section 4.1, we discus how both rising tones and syllables closed by an obstruent are

marked structures with respect to tone-segment interaction. In this perspective, a *[cv̌ʁ] constraint is exactly the type of constraint that is expected to emerge. Section 4.2 shows, however, that tone-driven epenthesis as a repair is vanishingly rare if not unprecedented. Finally, Section 4.3 discusses an important parallel to tone-driven epenthesis, namely intonation-driven epenthesis whereby a vowel is inserted to host part of an intonational tune. Although intonation-driven epenthesis has been purported more often than tone-driven epenthesis, it too is rare cross-linguistically.

4.1 The commonality of constraints on rising contours

The *[cv̌ʁ] constraint of Ghomala' is a particular manifestation of two cross-linguistic markedness: one pertaining to rising contours, and one pertaining to the ability of syllables closed by an obstruent to host tone. Let us begin with the former.

In a large-scale survey of contour tones, Zhang (2013) finds that if a language only allows one type of contour (falling or rising), languages which only allow surface falling tones (*n*=37) far exceed those which only allow surface rising tones (*n*=3). Furthermore, Zhang finds in numerous languages that rising tones have a more limited distribution than falling tones, such as with respect to syllable type or position within the word. In Mende, for example, a HL falling contour can occur on the final syllable of disyllabic word while a LH rising contour cannot. Such cross-linguistic findings warrant the phonological markedness scale in (5) (Yip 2002; Hyman 2007), where level tones are less marked than falling tones, which are less marked than rising tones.

(5) Markedness scale of tones (from less marked to more marked):
     {H,L} > F > R

Let us now consider the second markedness type. A large literature has emerged evaluating which syllable types are better hosts for tone and appear with a larger range of tone types, and which are worse. Surveys of contour tones Gordon (2001); Zhang (2013) find a cross-linguistic an implicational hierarchy. If a syllable that ends in a sonorant/resonant (what we shall abbreviate as 'CVN') can carry a contour, then a long vowel ('CVV') can carry a contour of "equal or greater tonal complexity" (Zhang 2013: 49). Moreover, if a syllable the ends in an obstruent (which we shall abbreviate as 'CVK') carries a contour, then CVN and CVV syllables can as well. Zhang shows that this implicational hierarchy is clearly seen in many Chinese languages. In the Changzhou variety of Wu Chinese [wuu], for example, five types of tone may appear on CVV/CVN syllables –

55, 13, 523, 24, and 45 (where 1 is the lowest and 5 the highest) – while only two tones may appear on CVK syllables – 23 and 5 (Wang 1988). This implicational hierarchy can be captured in a markedness scale parallel to the one posited above in (5). This is shown in (6).[7]

(6)   Markedness scale of a syllable's ability to host a tone contour:
CVV > CVN > CVK

Hyman (2007: 11) connects these two scales, stating that "in principle, the more complex ('marked') a tone is, the more likely it is to…be restricted to a hospitable TBU (e.g. a long, prominent, sonorous TBU)". One exemplification of these two scales interacting comes from Standard Thai [`tha`] (Gandour 1975), discussed by Yip (2002). Gandour follows a common approach to tone-segment interactions in Asian languages, dividing syllables into 'smooth' syllables (e.g. ending in a nasal, glide, or vowel, i.e. CVN) versus checked syllables (e.g. ending in a stop such as [p t k ʔ], i.e. CVK). There are five tones in Thai – high, mid, low, falling, and rising – but not all tones are allowed on both syllables types. This is summarized in Table 15.[8] This table shows that rising but not falling contours show a categorical ban in certain syllabic environment. These syllabic environments are exactly the ones we would expect from the markedness scale in (6).

Table 15: Thai tone type by syllable type (Y=possible, (*)=marginal, *=impossible) (Gandour 1975)

	Syllable	High	Mid	Low	Falling	Rising
a.	CVV	Y	Y	Y	Y	Y
b.	CVN	Y	Y	Y	Y	Y
c.	CVVN	Y	Y	Y	Y	Y
d.	CVK	Y	*	Y	(*)	*
e.	CVVK	(*)	*	Y	Y	*

To this, we can add the Ghomala' constraint *[cv̌ʀ] as one further instantiation of the interaction of these two scales.

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[7]Note that we specifically do not place short syllables (i.e. CV) in this scale. While Gordon (2001: 428) finds that that "if a language allows contour tones on CV, it also tolerates them on [CVK], [CVN], and CVV", there are exceptions to this, one of which is Ghomala' itself.

[8]Marginal words which Gandour (1975: 172) mentions include *kʰlâk* 'be crowded' with a falling tone on a CVK syllable and *káát* 'gas' (a loanword) with high tone on a CVVK syllable. Importantly, Gandour is explicit that "mid and rising tones never occur on a checked syllable".

While the above discussion is based around phonological typology, accumulated research in phonetics corroborates the particular markedness of [cv̌ĸ] sequences. It well-known that of contour tones, rising pitch takes longer to execute than falling pitch, and consequently a rising tone has greater duration on average (e.g. Sundberg 1973; Zhang 2013). Moreover, the main phonetic correlate of tone is fundamental frequency (i.e. f_0), and rich harmonic structures are crucial to the perception of f_0. Because sonorous segments such as vowels and sonorants possess richer harmonic structures than obstruents, pitch targets are better perceived on them. It therefore follows that syllables with obstruents would make for worse tone-bearing units generally, which would be compounded by the complexity of the tone. Taking these two aspects together, [cvĸ] structures may not provide enough sonorous material to adequately realize the rising tone within its allotted duration.

4.2 The rarity of tone-driven epenthesis as a repair

In response to such phonetically motivated pressures, phonological systems respond in various ways. The simplest case are those languages which unequivocally prohibit [cv̌ĸ]-type structures, which we saw in Thai (Table 15). In many languages, however, syllables closed by obstruents (or other inadequate hosts for contours) are 'repaired' in some way. One common repair is to lengthen the vowel (which may or may not neutralize a phonological distinction between short vs. long vowels). For example, Zhang (2013) cites lengthening in Mitla Zapotec [zaw] for syllables with rising contours, which does not apply to falling contours (Briggs 1961). Another common repair involves the compression, simplification, or flattening of the rising contour (see Zhang for examples). These two repairs are two sides of the same coin: there is a discrepancy between the amount of duration the syllable has versus the amount that the tone requires, and either the vowel lengthens or the tone compresses to accommodate.

In contrast, tone-driven epenthesis as a repair to a *[cv̌ĸ] constraint (or a similar such constraint) is exceedingly rare if not unprecedented. No such repair is mentioned in either of the large-scale typological surveys mentioned above (Gordon 2001; Zhang 2013). Nor does it appear in reference works on tone (e.g. Pike 1948; Fromkin 1978; Yip 2002; Wee 2019; *inter alia*), or on epenthesis (e.g. Broselow 1982; Itô 1989; Blumenfeld 2006; De Lacy 2006; Hall 2006; Hall 2011; *inter alia*). In fact, works which posit a maximally restrictive theory of epenthesis assume tone-driven epenthesis to be impossible/unattested (Blumenfeld 2006; Gleim 2019). Blumenfeld concludes that epenthesis is "used exclusively as a response to pressures of syllable structure, sonority sequencing, syllable contact,

and word minimality" (p. 5), but that "tone conditions cannot affect string structure" and therefore tone "cannot force epenthesis/syncope" (p. 41).

It is, therefore, quite remarkable that an epenthetic vowel in Ghomala' appears in order to host part of a pitch contour, rather than being solely due to segmental or syllabic markedness. Other than Ghomala', we are aware of only four potential cases of tone-driven epenthesis: in Wamey, Kejom, Barain, and Arapaho. Of these, only Wamey looks as convincing as the Ghomala' case.

Wamey [cou] (also called Konyagi/Coniagui) is a language of Guinea and Senegal, traditionally placed in the "Atlantic" group of the Niger-Congo phylum (and only distantly related to Ghomala'). In a recent paper, Rolle & Merrill (to appear) provide a number of arguments parallel to those developed for Ghomala', building on earlier description and insights found in Santos (1996). Like in Ghomala', in Wamey rising tones on closed syllables trigger epenthesis. This is evidenced by restrictions on the shape of roots. Wamey has a basic H vs. L tone contrast, and HL and LH contours are common. As summarized in Table 16, in isolation monosyllabic CVC-shaped roots may bear H, L, or HL tones, but no CVC root appears with a LH tone. At the same time, bisyllabic CVCə-shaped roots are not permitted with H, L, or HL patterns, but only appear with the LH tone.

Table 16: Complementary distribution in Wamey of bisyllabic CVCə vs monosyllabic CVC surface root shapes, based on tone (Santos 1996)

	Tone	Roots with surface [CVCə]		Roots with surface [CVC]	
a.	H	*cv́cə́		[cǽw̃]	'urinating'
b.	L	*cv̀cə̀		[cæ̀w̃]	'hiding'
c.	HL	*cv́cə̀		[cæ̂w̃]	'domestic animal'
d.	LH	[nkæ̀w̃ə́]	'dance'	*cv̌c	

This complementary distribution is naturally captured by a unified underlying representation /CVC/ for all four root types, plus tone-driven [ə] epenthesis to avoid a rising tone on a closed syllable. As in Ghomala' the overwhelming majority of roots are monosyllabic, and those CVCV structures which cannot be attributed to the epenthesis operation are either morphologically complex or loanwords.

We cannot attribute epenthesis here to segmental phonotactics, which would prohibit certain consonants in coda position. For any closed syllable bearing a rising LH tone, epenthesis is triggered. In Wamey, this applies with all coda consonants, not just by an obstruent as in Ghomala'. All consonants are otherwise

allowed in coda position, shown in (7). (Note that the prefixes are noun class markers, not relevant to our discussion).

(7) a. H [ì-gwǽlǽɓ] 'to talk a lot'
     b. L [ì-còɓ] 'to stick on'
     c. HL [æ̀-kæ̂ɓ] 'rubber vine'
     d. LH [æ̀-kə̀ɓə́] 'a species of owl' (*Otus leucotis*)

Moreover, Wamey also demonstrates morpho-phonological alternations which support the equivalency of coda-final and [ə]-final forms. For example, the suffix /-k/ (roughly equivalent to third person singular perfective) is one of several suffixes which show alternations of the type [-k]~[-kə́]. The data in (8) are representative for the distribution of the two variants: the [-k] form appears if the preceding vowel is high-toned (a), while the [-kə́] variant appears if the preceding vowel is low-toned (b). Such alternations are accounted for if we posit that the final schwa in (b) is inserted in order to avoid a rising tone on a syllable closed by /-k/ (see Rolle & Merrill to appear for extensive argumentation).

(8) Tone-driven alternations in Wamey (Santos 1996: 43)
     a. After [H]: ì-cǽs 'to suffer' → cǽsə́-k 'he suffers'
     b. After [L]: ì-tòk 'to eat' → tókə̀-kə́ 'he ate' (cf. *tókǎ-k)

While Wamey is a strong candidate for tone-driven epenthesis, the three other cases are much weaker. The first is another Grassfields language of Cameroon closely related to Ghomala', namely Kejom [bbk] (also called Babanki). The relevant data involve various verb inflections paradigms, found in Akumbu et al. (2020). For example, the authors analyze the imperative (specifically the non-indicative singular imperative) as involving a floating ⊕ tone which appears after the verb. Representative imperative data are in (9), with high-toned and low-toned roots. If ⊕ appears with a high-toned root (e.g. /lám/ 'cook'), then no overt marking is observed. However, if it appears with a low-toned root (e.g. /kùm/ 'touch'), then an overt inflectional suffix [-ə] appears. Note that in this example, there is high tone spreading onto the object's noun class prefix /kə̀-/, resulting in a surface mid tone.

(9) Non-indicative singular imperative in Kejom (Akumbu et al. 2020: 11)
     a. H root: /lám ⊕ kə̀-báyn/ → [**lám** kə̄-báyn] 'Cook the fufu!'
     b. L root: /kùm ⊕ kə̀-báyn/ → [**kùmə́** kə̄-báyn] 'Touch the fufu!'

Akumbu et al. (2020: 3) specifically characterize this distribution as lexically low verb roots having "acquired an epenthetic schwa to avoid the rising tone that would otherwise result from combining the root L with the H suffix tone of the imperative (*kǔm)". This would constitute tone-driven epenthesis.

However, one aspect of Kejom which makes it distinct from Ghomala' and Wamey is that this epenthesis process is not regular across verbal paradigms. For example, in the analogous context under negation, no epenthesis is found. As Akumbu et al. (2020) make clear, the same imperative floating ⊕ must be present in (10) as well, since it conditions tonal changes on the object.

(10)   Non-indicative negative singular imperative (Akumbu et al. 2020: 14)

    a.   /kɔ́ à lám ⊕ kɔ̀-báyn/ → [ká ꜜ**lám** kɔ̄-báyn] 'Don't cook the fufu!'

    b.   /kɔ́ à kùm ⊕ kɔ̀-báyn/ → [ká **kùm** kɔ̄-báyn] 'Don't cook the fufu!'

If tone-driven epenthesis were fully regular in Kejom, we would expect the unattested form *[kùmɔ́] in (b).

Another similar case which falls short of tone-driven epenthesis is found in Barain [bva] (Chadic: Chad – Lovestrand 2012). In Barain, tone alone cannot condition epenthesis but rather makes otherwise variable segmentally-driven epenthesis obligatory. Lovestrand (2012: 21) details the strict requirements on complex onsets and codas, showing that an epenthetic vowel is inserted to satisfy these requirements. In (11), the vowel [i] is inserted to break up the heteromorphemic consonant cluster.

(11)   Barain epenthesis (Lovestrand 2012: 44):
    /wīĺs-gà/ boil-do:3.m → [wīls**í**gà]

Speakers differ as to whether they manifest epenthesis in such heteromorphemic contexts. A coarse generalization is that younger speakers consistently insert epenthetic vowels in such cases while older speakers show more variation. This is exemplified in Table 17 with two speakers, A (of the younger generation, who consistently shows epenthesis) and B (of the older generation, who is more variable).

Importantly, Lovestrand (2012: 63) states that even "those speakers who allow the unlicensed cluster still prefer the epenthetic vowel in the case where not using the epenthetic vowel would create a word with fewer [tone-bearing units] than underlying tones". One example involves the imperfective aspect realized as a floating Ⓜ tone (row b from Table 17). When such a floating tone

is present, epenthesis is required by all speakers, and its absence is question-able/ungrammatical. In Barain, therefore, tone alone does not condition epenthesis *per se*, but rather increases the preference for it.

Table 17: Barain epenthesis co-driven by both segmental structure and tone (Lovestrand 2012)

	Morphemes	Gloss	Speaker A	Speaker B (Older gen.)
a.	/sééb-tì/	fish-DO:3.F	[séébítì]	[séébítì] ~ [séptì]
	/ēp-gà/	punish-DO:3.M	[èpìgà][a]	[èpìgà] ~ [èpgà]
	/páš-nù/	miss-DO:1.S	[pásùnù]	[pásùnù] ~ [pásnù]
b.	/dóp-Ⓜ-gà/	find-IPFV-DO:3.M	[dópìgà]	[dópìgà] (cf. [?][dópgà])[b]
	/sééb-Ⓜ-gà/	fish-IPFV-DO:3.M	[séébìgà]	[séébìgà] (cf. [?][sébgà], *[séèbgà])

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[a]A regular tonological rule changes M to L before L.

[b]Questionable forms are notated with a superscript [?], versus ungrammatical forms which are marked with an asterisk.

Finally, a similar case comes from Arapaho [arp] (Algonquian: USA – Cowell & Moss 2008). This superficially resembles tone-driven epenthesis, but Gleim (2019) argues is better understood as 'tone-driven retention'. Here, vowels that are otherwise expected to delete according to the regular phonology are retained if and only if they bear tone. Several such cases of tone-driven retention have previously been identified in Roettger & Grice (2019: 279-280), e.g. in Cheyenne [chy], Acoma [kjq], Konso [kxc], Japanese [jpn], and the Shanghainese variety of Wu Chinese [wuu]. In general, our presentation of the Arapaho data here follows the argumentation developed in Gleim (2019).

In Arapaho, certain morphemes idiosyncratically co-occur with a floating high tone, shown in Table 18. In many contexts, this floating high appears on an epenthetic vowel [i]/[u]. In row a., the epenthetic vowel and its surrounding consonants are in bold. In contrast, if the morpheme does not sponsor a floating tone, then no surface epenthetic vowel occurs (row b). Such data demonstrates a co-occurrence of floating tones and epenthetic vowels, which reasonably could be interpreted as tone-driven epenthesis.

However, Gleim (2019) argues that it is not epenthesis that is triggered by the floating tone here, but rather an epenthetic vowel is merely retained by the presence of tone which otherwise would have deleted (building on original observations in Cowell & Moss 2008: 16). The crucial evidence comes from a develar-

Table 18: Arapaho epenthetic vowels and floating tones (Gleim 2019)

a.	/tʃew-⊕see/	[tʃe**bí**see]	'to walk along'
	/oow-⊕see/	[hoo**wú**see]	'to walk downward'
	/nééʔeeθ-⊕nihíí-noo/	[nééʔee**sí**nihíínoo]	'that's what I'm saying'
b.	/étʃex-nówoʔ/	[hétʃe**sn**ówoʔ]	'small fish'
	/nih-bebíiθ-tii-t/	[nihbebíi**st**iit]	's/he fixed it'
	/tʃew-kóóhu/	[tʃe**bk**óóhu]	'run along'

ization process apparent also seen in this Table 18: velar segments /x/, /k/, /w/ become [s], [tʃ], [b] before front vowels [i] and [e]. Crucially, develarization takes place both before surface [i] (e.g. [tʃe**bí**see] in row a., where /w/→[b]), as well as opaquely applying where no surface vowel appears (e.g. [hétʃe**sn**ówoʔ] in row b., where /x/→[s]).

Gleim shows that the opacity can be accounted for straightforwardly if we assume a 'Duke-of-York derivation' (Pullum 1976), where an operation of vowel epenthesis applies first and uniformly, followed by floating tone docking and develarisation. After these operations, an operation of high vowel deletion takes place, but only if the high vowel does not bear high tone (hence, tone-driven retention). Because this deletion process can target an epenthetic vowel, the underlying form and the surface form look alike, characteristic of all Duke-of-York examples in the literature (i.e. of the type A→B→A).

To summarize, in Kejom tone-driven 'epenthesis' is not fully regular across the verb inflection paradigms, in Barain tone alone cannot condition epenthesis but rather only makes otherwise variable segmentally-driven epenthesis obligatory, and in Arapaho what resembles tone-driven epenthesis is actually tone-driven retention. Ghomala' and Wamey, in turn, do not have these shortcomings.

4.3 A parallel: intonation-driven epenthesis

A note-worthy process comparable to tone-driven epenthesis exists in the intonation literature: intonation-driven epenthesis. Here, a vowel is inserted to host part of an intonational tune (and not a lexical/grammatical tone *per se*).

Intonation-driven epenthesis can be situated within a larger discussion of 'text-tune' relationships in the intonation literature. In cases where there is a mismatch between the segmental structure (the 'text') and the intonational melody (the 'tune'), normally it is the melody which accommodates (e.g. through truncation).

A growing literature shows evidence for the opposite as well: segmental structure changing to accommodate the intonation (Roettger 2017; Grice et al. 2018; Roettger & Grice 2019).

To illustrate, consider a recent study of Tunisian Arabic intonation (Hellmuth 2022). Yes-no questions are commonly realized with a rise-fall intonational complex (i.e. L*+H H-L%) at the right edge of an intonational phrase. When this intonational complex appears, it often co-occurs with an epenthetic vowel to which part of this complex docks. An example of phrase-final [ə] epenthesis is in (12).

(12)   nkemmil   tˤuːl   →   [nkemmil tˤuːlə:]
       I-continue straight.ahead
       'Should I go straight ahead?' (Hellmuth 2022)

Epenthesis only appears in the context of this complex rise-fall contour, and even then only half the time. Importantly, it *never* appears when there is only a simple rise or simple fall, even in the context of a yes/no question. Tunisian Arabic thus shows clear co-variation between a final vowel and a complex pitch event, suggestive of intonation-driven epenthesis.[9]

What unifies tone-driven and intonation-driven epenthesis is that both are attributable to a functional pressure to cultivate segmental environments best suited for realizing pitch targets. Still, despite this functional motivation intonation-driven epenthesis is quite rare within the world's languages, though there are more purported cases than for tone-driven epenthesis. See the above-mentioned sources for several other purported cases of intonation-driven epenthesis (especially Roettger & Grice 2019).

5 Conclusion

This chapter focused on a little-known tonological rarity: tone-driven vowel epenthesis. We showed that in Ghomala', an epenthetic vowel is inserted to avoid a rising tone on syllable closed by an obstruent, e.g. /gǒp/ → [gɔ̀pɔ́] 'chicken', but never triggered in other tonal contexts. We supported tone-driven epenthesis with evidence from root phonotactics and morpho-phonological alternations

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[9]Note, however, that Hellmuth (2022) deliberates over the final [ə] in examples like (12) as to whether it is intonation-driven epenthesis or intonation-driven retention (analogous to Arapaho in Table 18). She ultimately concludes that it is "rather a 'question vowel' particle of some type", analogous to similar interrogative clitics in the linguistic area. This speaks to the analytic indeterminacy of epenthesis, which is notoriously difficult (Morley 2015). Regardless, these Tunisian Arabic data suffice to illustrate intonation-driven epenthesis for our purposes.

which show that when a rising tone is modified the epenthetic vowel is lost (i.e. complete co-variation). Finally, we situated these Ghomala' patterns within a larger cross-linguistic perspective. We demonstrated that the Ghomala' constraint against [cv̌ʀ] structures has much typological and phonetic support, given the general markedness of rising contours, as well as the markedness of obstruent-final syllables acting as tone-bearing units. While the motivation for tone-driven epenthesis is clear, we examined all other purported cases of tone-driven epenthesis and showed that nearly all of them fall short compared to Ghomala'. We ended our study by comparing the Ghomala' patterns to a similar intonation-driven epenthesis, which, too, is seldom reported for the world's intonational systems.

There is one matter which has been conspicuously absent from our discussion thus far: if tone-driven epenthesis is so exceedingly rare, why? Its existence in Ghomala' entails that we cannot deny it as a universal constraint, requiring a more nuanced explanation. One possibility we would like to put forward involves functional load (Hockett 1955; 1966; Wedel et al. 2013; Hall et al. 2019). Cross-linguistically, lexical and functional meaning cued by tone can also be cued simultaneously by a co-occurring segmental component, and only more rarely cued by tone alone. Because of this, if tone fully or partially deletes in some environment, the meaning can still be recovered in general. In this way, the functional load of tone is quite low. In many tonal languages, therefore, there is little reason to excessively maintain tone contrast if other markedness considerations come into play. If there is enough segmental material to differentiate the morpheme from other paradigmatically-related morphemes (e.g. all nominal roots, or all tense/aspect suffixes), then adding more segmental material via epenthesis may be costlier than being faithful to the underlying tone pattern.

In short, because of the low functional load of tone, in most languages if the H portion of a hypothetical [cv̌ʀ] sequence were simply deleted, little information would be lost to correctly identifying the intended meaning. At this point, such an explanation remains tentative, and a dedicated study is required before it can be evaluated further.

Abbreviations and glossing

´ (H)	high tone	CL	noun class
↓´ (ꜜH)	downstepped high	COND	conditional
⁻ (M)	mid tone	COP	copular
` (L)	low tone	DEF	definite
`° (L°)	level low tone	DEPR	depreciative
ˆ (F)	falling tone	DO	direct object
ˇ (R)	rising tone	F	feminine
Ⓗ	floating high tone	H_PST	hodiernal past
Ⓜ	floating high tone	INF	infinitive
Ⓛ	floating low tone	INFL	inflection
C	consonant	IPFV	imperfective
V	vowel	M	masculine
N	sonorant (in syllable)	PROG	progressive
K	obstruent (in syllable)	RECIP	reciprocal
N_1	first noun in phrase	S	singular
N_2	second noun in phrase		

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