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Biblical Hebrew segholates

Universal and language-specific effects

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Abstract

Most studies agree that the input (i.e. the base) of a segholate paradigm in Biblical Hebrew is prosodically CVCC. However, such an input leads to an analysis that does not comply with universal typology of vowel strength, an analysis where vowel alternation not only affects a strong (stressed) position but also triggered by a (weak) epenthetic vowel. In this paper, we provide an alternative analysis, which postulates the surface singular form as the input of the paradigm and eliminates the unnatural nature of the morphophonology of segholates.

Keywords

Biblical Hebrew – segholates – universal principles – paradigms – stress – foot structure – (non-)moraic codas – gutturals

1 Introduction

Segholate nouns are unique among the nouns in Biblical Hebrew (hereafter BH) with regard to their stress pattern and morpho-phonological alternation.[1]

1 The segholate class of nouns got its name from the vowel diacritic *seghol*, phonetically [ɛ], which appears in the second syllables of the singular forms in all the (guttural-free) paradigms (see (1)). We limit our discussion here to segholates in Biblical Hebrew; for analyses of segho-

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There are three phonological properties that together distinguish segholates from other nouns (see Appendix A for phonetic charts): (i) stress is penultimate in the bare stem (e.g. *zɛ́rɛm* 'downpour'); (ii) the vowels in the bare stem are mid (e.g. *bósɛm* 'spice'), unless lowered in the environment of a guttural (e.g. *póʕal* 'work'); and (iii) the second vowel in the plural base is /ɔ/ regardless of the stem vowel (e.g. *zərɔm-ím* 'downpours').

The segholates are a nominal class (traditionally called *mishqal*; literally 'weight'), and a class often includes several subclasses, where each subclass has a slightly different paradigm (see Zadok and Bat-El 2015 for the notion of sub-classes in the verb system of Modern Hebrew). There are 17 segholate paradigms in BH (see Appendix B), out of which 10 exhibit the effect of guttural consonants. We focus here on guttural-free paradigms, to which we refer as *model paradigms*; paradigms with gutturals are addressed in § 4.

The 7 model paradigms are distinguished by morpho-phonological vowel alternation in three representative morphological categories: singular, plural, and possessive. Below are examples of each of the 7 paradigms, and their distribution in our database.[2]

(1) Model segholate paradigms (n=246)

	Vocalic patterns	Singular CVCVC	Plural CVCVC	Possessive CVCC		Distribution n	%
a.	ɛɛ–əɔ–i	zɛ́rɛm	zərɔm-ím	zirm-í	'downpour'	138	56.1 %
b.	ɛɛ–əɔ–a	yɛ́lɛð	yəlɔð-ím	yald-í	'child'	34	13.8 %
c.	ɛɛ–əɔ–ɛ	nɛ́xɛð	nəxɔð-ím	nɛxd-í	'progeny'	3	1.2 %
d.	eɛ–əɔ–i	nézɛr	nəzɔr-ím	nizr-í	'crown'	25	10.2 %
e.	oɛ–əɔ–ɔ	bósɛm	bəsɔm-ím	bɔsm-í	'spice'	38	15.5 %
f.	oɛ–ɔɔ–ɔ	ʃórɛʃ	ʃɔrɔʃ-ím	ʃɔrʃ-í	'root'	2	0.8 %
g.	oɛ–əɔ–u	qómɛsˤ	qəmɔsˤ-ím	qumsˤ-í	'fist'	6	2.4 %

The ***singular forms*** in (1) are all CV_1CV_2C with penultimate stress, where V_2 is /ɛ/ and V_1 varies among the three mid vowels /ɛ/, /e/, and /o/. On the basis of

lates in Modern Hebrew, see Bat-El (1989, 2012), Bolozky (1995), Falk (1996), and Faust (2011, 2014).

2 Our database consists of the 519 segholate nouns, which are classified in Avineri (1976) as biblical. The association of each segholate with its paradigm is based on Barkali (2000). Glosses are drawn from *The Enhanced Brown-Driver-Briggs Hebrew and English Lexicon*.

V_1, we distinguish between unrounded and rounded sets of paradigms, where in the unrounded set (1a–d), V_1 is /ɛ/ or /e/, and in the rounded set (1e–g), V_1 is /o/. There are more nouns in the unrounded sets than in the rounded ones, a distribution that correlates with markedness relations, where the unmarked segment (here unrounded vowels) is more common than its marked counterpart; 81 % (200/246) of the nouns in the model paradigms in (1) belong to the unrounded set, and 77 % (399/519) in the entire database, which includes forms with gutturals.

The base of the ***plural form*** is prosodically identical to that of the singular, i.e. CV_1CV_2C, where V_2 is /ɔ/ and V_1 is a schwa (with the exception of two forms in (1f), where V_1 is also /ɔ/). The plural template is thus CəCɔC-im/oθ, sharing the plural suffixes *-im* and *-oϑ* with the other nouns in the language.

The base of the ***possessive form*** is CVCC, where V varies among five vowels: /i/, /ɛ/, /a/ in the unrounded set and /ɔ/ and /u/ in the rounded set. The singular–possessive vowel correspondence is given below, with the letters a-g corresponding to the paradigms in (1) above:

(2) Singular–possessive vowel correspondences

Paradigm set	Singular		Possessive
Unrounded	eɛ	d	i
	ɛɛ	a	i
	ɛɛ	c	ɛ
	ɛɛ	b	a
Rounded	oɛ	e,f	ɔ
	oɛ	g	u

Previous analyses of BH segholates have been subject to debate from both diachronic and synchronic perspectives. However, there seems to be a consensus with regard to the prosodic structure of the underlying representation (UR). All studies agree that the underlying representation of a segholate paradigm is prosodically CVCC, as in the possessive base, where V is one of the corner vowels (i, u, a) diachronically (Malone 1971, 1993, Muraoka 1976, Revell 1985, Garr 1989), or the possessive stem's vowels synchronically (Coetzee 1999a,b, Bye 2003, Green 2004). In this paper, we focus on the synchronic analysis.

(3) Underlying representation in previous synchronic analyses

	UR	Singular CVCVC	Possessive CVCC	
a.	/zirm/	zɛ́rɛm	zirm-í	'downpour'
b.	/yald/	yɛ́lɛð	yald-í	'child'
c.	/nɛxd/	nɛ́xɛð	nɛxd-í	'progeny'
d.	/nizr/	nézɛr	nizr-í	'crown'
e.	/bɔsm/	bósɛm	bɔsm-í	'spice'
f.	/ʃɔrʃ/	ʃórɛʃ	ʃɔrʃ-í	'root'
g.	/qumsˤ/	qómɛsˤ	qumsˤ-í	'fist'

The underlying representations in (3) are bound stems, which undergo prosodic and segmental alternation in the singular form. Prosodically, the underlying CVCC gains a V-slot, thus resulting in a surface CVCVC form. Segmentally, the rounded vowels (/ɔ/, /u/) surface as /o/, and the unrounded vowels (/i/, /a/, /ɛ/) surface as /ɛ/, with the exception of 25 forms in paradigm (3d), where /i/ surfaces as /e/.

The traditional analysis goes roughly as follows: after stress is assigned to the only syllable in the CVCC input, a vowel /ɛ/ is inserted between the two consonants, either due to the prohibition against complex codas (Coetzee 1999a,b, Bye 2003), or to a lexically specified trochaic template (Green 2004). Then, the underlying vowel changes its quality, mostly due to some process of assimilation (Coetzee 1999a,b, Bye 2003). The derivation of the singular form of paradigm (3a) would thus be /zirm/ –stress→ zírm –epenthesis→ zírɛm –vowel alternation→ *zɛ́rɛm*, and that of (3f) would be /ʃɔrʃ/ –stress→ ʃɔ́rʃ –epenthesis→ ʃɔ́rɛʃ –vowel alternation→ *ʃórɛʃ*.

Such synchronic analysis of BH segholates seems to comply with the historical development (see § 2.1). However, it does not conform to the generalizations in (4) below, drawn from universal typology of vowel strength (see also § 2.3).

(4) Universal typology of vowel strength
  a. *Epenthetic vowels are weak*—they are often ignored in stress assignment and may be subject to alternation or to vowel echoing (as they are not specified for segmental content in the underlying representation).
  b. *Vowels in stressed syllables are strong*—they often resist alternation thus preserving their underlying segmental content.

This correlation between epenthetic—weak on the one end of the scale, and stressed—strong on the other, is reversed in the traditional analysis of BH segholates. First, while the weak epenthetic vowel is expected to be the target of vowel alternation, in Biblical Hebrew, according to most analyses, it serves as a trigger of assimilation. Second, the strong-stressed vowel in the singular form should resist alternation, but instead, it changes its quality. That is, universal typology predicts the derivation /zirm/ → zírm → **zírim*, where the weak-epenthetic vowel gets its features from the strong-stressed vowel, but previous analyses propose /zirm/ → zírm → zírɛm → *zɛ́rɛm*, where the weak-epenthetic vowel affects the strong-stressed one.

It should be noted that among the various studies of BH segholates (see § 2), there is one unique voice—DeCaen (1992), which criticizes the postulation of CVCC as the underlying representation, not only in a synchronic analysis but also in a diachronic analysis. Although his arguments differ from ours, we certainly accept DeCaen's view that "there is no a priori reason for choosing one model over the other" (p. 24), i.e. CVCC or CVCVC as an underlying representation.

In this paper we provide an alternative analysis of the segholate paradigms that *better fits with universal typology*. At the base of our analysis is the proposal that the singular form serves as the input for the plural and the possessive forms; that is, the singular form is the stem of the paradigm.

In the ensuing § 2, we highlight the similarities between previous diachronic (§ 2.1) and synchronic (§ 2.2) analyses of BH segholates, recapitulating our argument that the synchronic analysis does not comply with universal principles (§ 2.3). We thus propose our alternative analysis in § 3, within the framework of Optimality Theory (OT), where the singular stem is the input from which the plural and the possessive forms are derived. Our analysis attends to the unique stress pattern of the singular forms (§ 3.1), and the alternation in the prosodic structure and the vocalic pattern across the paradigms (§ 3.2). In § 4 we focus on segholates with gutturals, first displaying the data and the generalization (§ 4.1) and then providing an OT analysis (§ 4.2). Concluding remarks are given in § 5.

2 Synchrony and diachrony converge in previous analyses

In this section we highlight the similarities between the accepted diachronic (§ 2.1) and the classic synchronic (§ 2.2) analyses of BH segholates, and review the arguments that support the convergence of diachrony and synchrony. We argue, however, that the synchronic analysis does not fit with universal principles (§ 2.3).

2.1 *The emergence of segholates: a diachronic analysis*

In the reconstructed Pre-Hebrew, estimated to the Early Bronze Age (Kitchen et al. 2009), all words ended in a vowel, either short or long. However, somewhere along the development from Pre-Hebrew to BH, final short vowels were omitted (Malone 1971, Churchyard 1999, Blau 2010). Consequently, words with a penultimate open syllable turned into words ending in a CVC syllable (5a,b), and words with a penultimate closed syllable turned into words ending in a CVCC syllable (5c). The latter type evolved into the segholate nouns, the largest group of nouns in BH (Avinery 1976, Joüon 1991).

(5) The emergence of segholates (ω stands for 'word')

	Pre-Hebrew	⇒	Biblical Hebrew	
a.	… CV́.CV}$_ω$		… CV́C}$_ω$	
b.	… CV́:.CV}$_ω$		… CV́:C}$_ω$	
c.	… CV́C.CV}$_ω$		… CV́CC}$_ω$	Segholates

BH disfavored the relatively marked word-final consonant clusters, and therefore, final short vowel omission was accompanied by the epenthesis of /ɛ/.[3] Stress, which was penultimate in Pre-Hebrew, stayed in its position throughout this change, yielding final stress pattern in C-final words (5a,b), with the exception of segholates (5c); with the epenthetic vowel, the segholates became the only noun class with penultimate stress.

In addition to epenthesis, there was also vowel change in the bare stem: *a* → *ɛ* (6a), *i* → *ɛ* (6b) or *e* (6c), and *u* → *o* (6d).

(6) The development of segholates bare stems

	Pre-Hebrew	V-omission	Epenthesis	V-change		
a.	ʃámna	ʃámn	ʃámɛn	ʃɛ́mɛn	(a → ɛ)	'oil'
b.	díʃna	díʃn	díʃɛn	dɛ́ʃɛn	(i → ɛ)	'fat ashes'
c.	nízra	nízr	nízɛr	nézɛr	(i → e)	'crown'
d.	ʃúrʃa	ʃúrʃ	ʃúrɛʃ	ʃórɛʃ	(u → o)	'root'

3 There seem to be three epenthetic vowels in BH (in non-guttural environment): /ə/ in an open syllable, /ɛ/ in a closed final syllable (in segholates), and /i/ in a closed non-final syllable (e.g. *divrej-* 'words of').

The vowel change is often attributed to a process of assimilation (vowel harmony) between the epenthetic vowel /ɛ/ and the stem vowel. The assimilation is complete or partial: in paradigms (6a) and (6b) assimilation is complete, where the vowel (/a/ or /i/) is changed to /ɛ/; in paradigms (6c) and (6d) assimilation affects only the height feature, where /i/ is lowered to /e/ and /u/ to /o/.

2.2 *Previous synchronic analyses of segholates*

With the assumption that the UR of the paradigm is prosodically CVCC, earlier synchronic analyses of BH segholates (Coetzee 1999a,b, Bye 2003, Green 2004) replicate the historical development. The derivation goes as follows:

(7) Synchronic derivation of segholates (previous analyses)

UR	**/zirm/ (1a)**	**/bɔsm/ (1e)**
Stress assignment	zírm	bɔ́sm
Epenthesis	zírɛm	bɔ́sɛm
Vowel alternation	z**ɛ́**rɛm	b**ó**sɛm
PR	[zɛ́rɛm]	[bósɛm]

In most studies, epenthesis is attributed to the prohibition on a complex coda. This prohibition is limited (synchronically and diachronically) either to nouns or to non-derived environments, because complex codas do exist in BH (Offer 1992); they are found in verbs with the 2nd person feminine suffix *-t* (e.g. *kɔħal-t* 'you FM.SG painted') and in truncated verbs (e.g. (*way*)*yerd* '(and he) went down'; cf. the full form *yereð*). In addition, there are three exceptional nouns with a complex coda—*qoʃtˤ* 'costus (name of a plant)', *nerd* 'lavender (name of a plant)', and *ʔard* 'a descendant of Benjamin'—which failed to undergo the epenthesis. The presence of these forms with complex codas has led Green (2004) to attribute epenthesis in segholates to a lexically assigned trochaic template, rather than to the complex coda.[4] Either way, whatever the trigger of epenthesis is, the UR of the segholates is CVCC.

4 Also DeCaen (1992) indicates that these examples with surface complex codas are counter-evidence for postulating CVCC as the underlying representation. However, as noted, in all cases but three (all names), the complex coda is found in verbs and in derived environment, either suffixation or truncation. Theoretical frameworks like Lexical Phonology or Optimality Theory can accommodate these surface complex codas within a CVCC approach.

To conclude, according to previous analyses, there are at least two reasons to assume that the UR of the segholates is CVCC with different vowel qualities:

a. Stress: Epenthetic vowels are often invisible to the stress system (Broselow 2008). Thus, the fact that the final syllable in the singular form is unstressed suggests that the vowel is epenthetic.

b. Morpho-phonology: Postulating the possessive form to be the UR allows a systematic derivation for 89% of the singular nouns (see Appendix D).

2.3 *Anti-universal aspects in earlier analyses of BH segholates*

Stressed vowels and epenthetic vowels are on the two edges of the scale of phonological strength, where stressed vowels are strong and epenthetic vowels are weak. This dichotomy is, however, reversed in the analyses of segholates reviewed above, where the epenthetic vowel behaves as a strong vowel being the trigger of vowel alternation, and the stressed vowel behaves as a weak vowel by failing to resist alternation.

Stressed vowels (i.e. vowels in stressed syllables) are perceptually prominent due to the acoustic properties of stress—increased length, loudness, and/or pitch contour (depending on the language). This perceptual prominence grants vowels in stressed syllables phonological strength, reflected in resistance to phonological neutralization (Steriade 1994, Beckman 1998; see review in Barnes 2006). English provides a well-known example of this universal tendency, where non-final vowels are reduced to a schwa unless they are stressed (primary or secondary stress); that is, stress protects the vowels from reduction, where reduction is actually weakening (Crosswhite and Jun 2001, Crosswhite 2004). Similarly, in Belarusian (Krivitskii and Podluzhnyi 1994 in Crosswhite 2004), /e/ and /o/ preserve their contrast in a stressed syllable, but are neutralized to /a/ when unstressed (e.g. *nóɣ-i* 'legs'—*naɣ-á* 'leg', *rék-i* 'rivers'—*rak-á* 'river').

Epenthetic vowels are phonologically weak, and are often analyzed as lacking segmental content, thus phonologically represented with an empty V-slot (Anderson 1982, Clements and Keyser 1983). In Karitiana (Storto 1999), for example, stress is final, with the exception of a group of forms with penultimate stress. For these forms, it is assumed that the UR is CVCC, where epenthesis follows the stress rule; this is exactly what has been proposed for BH (see review in § 2.2 above). However, as predicted by universal principles, but unlike in BH, the epenthetic vowel in Karitiana, presumably an empty V-slot, copies its segmental content from the base vowel (e.g. /terp/ → *térep* 'straight', /bakp/ → *bákap* 'hanging', /horp/ → *hórop* 'long'). This analysis accounts not only for the unique stress pattern of these words but also for the fact that whenever stress is penultimate the two surface vowels are identical.

The weakness of epenthetic vowels is attributed to the absence of segmental features. Thus, an epenthetic vowel cannot trigger assimilation or vowel harmony, but it can trigger processes referring to prosodic slots only, such as post-vocalic spirantization in Tiberian Hebrew, which applies after any vowel, regardless of its features (Hayes 1986). However, being weaker than a specified vowel, a schwa can be declared to be too weak for carrying stress, by virtue of not having any features.

The two universal generalizations of strength relevant to the present discussion are thus as follows:

a. Strength: A vowel in a stressed syllable (strong position) resists alternation

b. Weakness: An epenthetic vowel cannot trigger segmental alternation.

These generalizations are not exception free. In many Italo-Romance languages/dialects, a stressed vowel alternates in the environment of a following unstressed high vowel, as in Servigliano *métto* 'I put'—*mítti* 'you put', *spósa* 'wife'—*spúsu* 'husband' (see Kaze 1991 and references therein).[5] This process, has been argued to enhance the perceptibility of the unstressed vowel (Walker 2005) and preserve contrast (Cole 1998), in particular in dialects like Calvello, where final vowels merged to schwa (Mascaró 2016). Viewing grammar as a system of competing motivations, this phenomenon suggests that stressed vowels may undergo alternation for more important purposes. However, we do not see any such purpose in the paradigm of segholates. In addition, we have not seen a purpose for an epenthetic vowel to trigger assimilation, in particular assuming that epenthetic vowels are featureless in the UR, consisting of an empty V-slot, and therefore do not have the segmental content required for triggering alternation.

These two generalizations are severely defied in earlier analyses of BH segholates, because instead of the expected Karitiana-like derivation, i.e. /zirm/ → zírm → **zírim*, we get a typologically unnatural derivation where the epenthetic vowel affects the stressed vowel. For this reason we propose an alternative analysis, one which does not defeat universal typology.

5 This phenomenon, which developed from the historical process of metaphony (Maiden 1987), has been studies with reference to variation within the Italo-Romance languages/dialects and the phonological theory most suitable to account for the alternation (e.g. Maiden 1987, Cole 1998, Kaze 1991, Calabrese 1998, Walker 2005; see also the papers in Torres-Tamarit et al. 2016).

3 A universally-based analysis of BH segholates

In a sharp contrast with previous analyses, we propose that the input of a segholate paradigm is prosodically and segmentally identical to the surface representation of the singular forms. This proposal requires to address the unique penultimate stress in the singular form (§ 3.1) and the morpho-phonological alternation in the vocalic pattern and prosodic structure (§ 3.2).

It is important to emphasize at this juncture that the BH nominal (and verbal) system is mostly templatic; that is, the surface structure of nouns is restricted by constraints that assign the prosodic structure and vocalic pattern, as in other Semitic languages (McCarthy 1979, 1981, McCarthy and Prince 1993, Ussishkin 1999, 2000, Bat-El 2003, 2011). Segholates form a noun class (*mishkal*), which includes several subclasses (see the paradigms in (1)), and thus can be prosodically and segmentally characterized.

We also wish to note that we do not dismiss the phonological motivation that leads to the historical change, nor that this motivation has residues. However, we contend that the phonological motivation that was relevant in the course of change was no longer pertinent in the synchronic grammar of BH. As such, the segholate paradigms are similar to verb paradigms, where some morpho-phonological alternations are allomorphic with no phonological environment, in both the inflectional paradigm (e.g. *kɔϑáv—koϑév* 'to write 3MS.SG.PAST—MS.SG.PARTICIPLE') and the derivational paradigm (e.g. *kɔϑáv—hiϑkattév* 'to write—to correspond').

3.1 *Stress*

The nominal system of BH consists of many configurations (Bat-El 2011), i.e. combinations of prosodic structure, vocalic pattern, and affix (if any); for example, CɔCɔC (e.g. *gɔmɔ́l* 'camel', *dɔvɔ́r* 'word'), taCCiC (e.g. *talmíd* 'scholar', *taxríx* 'robe'), and miCCɔC (e.g. *mixtɔ́v* 'writing', *miɣdɔ́l* 'tower'). All nouns in these configurations bear final stress and they all end in a consonant in the underlying represetnation.[6] Following earlier studies, stress in BH is usually final in C-final noun stems and penultimate in V-final nouns (McCarthy 1979, Hayes 1980, 1995, Dresher 1981, 2009, Rappaport 1984, Halle and Vergnaud 1987, Churchyard 1999, Bat-El 2018). Segholates are, of course, excluded from this generalization, though according to previous analyses (§ 2.2), only in the surface representation.

6 In the surface representation, a glottal stop or a /t/ are deleted in word final position (e.g. /sukkat/ → *sukkɔ́* 'booth', /lɔviʔ/ → *lɔví* 'lion'), thus leading to a vowel-final words with final stress.

For the assignment of stress, there are two alternative analyses of feet, differing in the type of the consistent component. In one analysis (8a), the foot structure is consistent across the board, and in the other (8b), it is the foot type that is consistent across the board. These two options are presented in (8) below.

(8) Two alternative foot structures for final stress

	Foot structure	Foot type	C-final–final stress	V-final–penult. stress
a.	Syllabic	Trochaic/Iambic	… [CV(C).**CVC**]$_{Ft}$ Syllabic foot; Iamb	… [**CV**(C).CV]$_{Ft}$ Syllabic foot; Trochee
b.	Syllabic/Moraic	Trochaic Moraic foot	… CV(C)[**CVC**]$_{Ft}$	… [**CV**(C).CV]$_{Ft}$ Syllabic foot; Trochee

The analysis in (8a) assumes a binary syllabic foot across the board, with an inconsistent foot type (trochaic/iambic). In this analysis, final stress is obtained by an iamb foot, while penultimate stress is obtained by a trochee foot. The analysis in (8b) assumes a trochaic foot across the board, with an inconsistent foot structure (syllabic/moraic). C-final words contain a moraic foot in their right edge, and therefore bear a final stress, and V-final words contain a trochee syllabic foot, which assigns the penultimate stress.[7]

We adopt the analysis in (8b), where all feet are trochaic, as we see the inconsistent foot structure (syllabic/moraic) as the lesser of the two evils; systems with mixed foot type (trochaic/iambic) are rare, while those with mixed foot structure (syllabic/moraic) are more common.

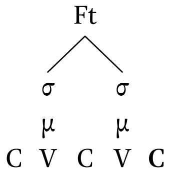
Whatever morpho-phonological analysis one adopts, the stress system of segholates must be unique in one property or another. In most analyses, it is the abstract underlying representation (i.e. CVCC) combined with rule ordering (stress before epenthesis). In contrast with earlier analyses, we limit the lexically specified difference between segholates and non-segholates to whether the final coda gains a mora. In non-segholates (9b), the final coda is moraic, while in segholates (9a) it is not moraic. Assuming the footing in (8b) above,

7 A mora is a weight unit, where heavy syllables (CV: and CVC) consist of two moras, while light syllables (CV) consist of one. The unmarked foot is binary, consisting of two moras (a heavy syllable or two light syllables) or two syllables. Syllabic feet can be trochaic (strong–weak) or iambic (weak–strong) and moraic feet can fit either pattern.

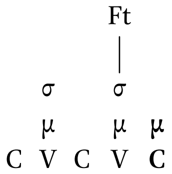
the trochaic foot spans a single bimoraic syllable in non-segholates (9b), but two syllables in segholates (9a).

(9) Moraic structure and footing: Trochaic feet across the board

a. Segholates



b. Non-segholates



Assuming this structure for segholates, the historical development from pre-Hebrew to BH, which involved final vowel deletion (§2.1), did not involve refooting.

(10) Foot persistent in the change from Pre-Hebrew to Biblical Hebrew

	Pre-Hebrew	**Biblical Hebrew**	
a. Non-segholates:	gɔ[mɔ́la]$_{\mathrm{Ft}}$	gɔ[mɔ́l]$_{\mathrm{Ft}}$	'camel'
b. Segholates:	[díʃna]$_{\mathrm{Ft}}$	[déʃɛn]$_{\mathrm{Ft}}$	'fat ashes'

We thus conclude this section with the proposal that segholate nouns take penultimate stress in the singular forms because their final consonant is not moraic. The strong foot is trochaic in both cases, but due to the minimal contrast in moraic structure, the foot consists of two syllables in segholates but one bimoraic syllable in non-segholates.

This contrast is minimal not only in terms of phonological representation, but also in grammatical terms, within the constraint-based approach of Optimality Theory (Prince and Smolensky 1993/2004); see Appendix E for the list of constraints used in this paper. Following Hayes (1989), coda consonants are not moraic in the underlying representation, but rather gain a mora via the constraint Weight-by-Position (W-by-P), which assigns a mora to consonants according to their position in the syllable, i.e. coda position. A candidate with an added mora respects W-by-P but violates the Depμ, which prohibits mora addition. The presence or absence of a moraic coda, and thus the contrast between heavy and light syllables, is relevant also to the constraint Weight-to-Stress (W-to-S), which expresses the natural attraction of stress to heavy syllables.

The difference between segholates and non-segholates can be represented in terms of co-phonologies (Orgun 1996, Inkelas 1998, Anttila 2002, Inkelas and Zoll 2005), with different constraint rankings for different classes of words: W-by-P » Depμ for non-segholates and Depμ » W-by-P for segholates. It can also be represented with indexed constraints (McCarthy and Prince 1995, Itô and Mester 1999, 2003), as in (11) below, with a segholate-specific constraint Depμ$^{[segol]}$.[8]

(11) Stress in the singular forms

Non-segholates:

/gɔmɔl/	Depμ$^{[segol]}$	W-to-S	W-by-P	Depμ
a. ☞ gɔ[mɔ́l$_{\mu}$]				*
b. [gɔ́mɔl$_{\mu}$]		*!		*
c. [gɔ́mɔl]			*!	

Segholates:

/bosεm/	Depμ$^{[segol]}$	W-to-S	W-by-P	Depμ
a. bo[sέm$_{\mu}$]	*!			*
b. [bósεm$_{\mu}$]	*!	*		*
c. ☞ [bósεm]			*	

The crucial ranking between W-by-P above Depμ accounts for the final stress in non-segholates, and the crucial ranking of Depμ$^{[segol]}$ above W-by-P forces the disyllabic (trochaic) foot in segholates, and thus penultimate stress.

8 The same analysis applies to the feminine forms with the suffix *-εϑ*, where stress is always penultimate; e.g. *miʃmér-εϑ* 'guard', *miʃqól-εϑ* 'leveling instrument', *biqqór-εϑ* 'punishment after examination'. Unlike traditional analyses, and in par with the analysis proposed here, we propose that the suffix is /-εt/ (*-εϑ* after spirantization), and not /-t/ followed by epenthesis.

3.2 *Allomorphy in the model paradigms*

In the inflectional paradigm of BH verbs, the representative of a paradigm (often called *citation form*) is the 3rd person past form (e.g. *kɔϑav* 'to write 3MS.SG.PAST'), because it is an affix-free surface form. For the same reason, the singular form is the representative of a segholate paradigm. Indeed, a paradigm representative is not necessarily the input of the paradigm (or the underlying representation) from which surface forms are derived. However, we argue that this is the case with segholates.

There are three segholate configurations in BH: CɛCɛC, CoCɛC, and CeCɛC, where CɛCɛC is the most common one, with 175 forms (71%); CoCɛC is next in line with 46 forms (19%); and CeCɛC is the least common with 25 forms (10%). Again, as in the verbal system, where a configuration may consist of several sub-paradigms (Zadok and Bat-El 2015), CɛCɛC and CoCɛC consist of three paradigms each, and CeCɛC consists of one paradigm. The paradigms are repeated below with reference to the configurations and the vocalic pattern in each form of the paradigm.

(12) Configurations and sub-paradigms

Configuration		**Vocalic patterns**	**Singular CVCVC**	**Plural CVCVC**	**Possessive CVCC**	
CɛCɛC (n=175)	a.	ɛɛ–əɔ–i	zɛ́rɛm	zərɔm-ím	zirm-í	'downpour'
	b.	ɛɛ–əɔ–a	yɛ́lɛð	yəlɔð-ím	yald-í	'child'
	c.	ɛɛ–əɔ–ɛ	nɛ́xɛð	nəxɔð-ím	nɛxd-í	'progeny'
CeCɛC (n=25)	d.	eɛ–əɔ–i	nézɛr	nəzɔr-ím	nizr-í	'crown'
CɛCɛC (n=46)	e.	oɛ–əɔ–ɔ	bósɛm	bəsɔm-ím	bɔsm-í	'spice'
	f.	oɛ–ɔɔ–ɔ	ʃórɛʃ	ʃɔrɔʃ-ím	ʃɔrʃ-í	'root'
	g.	oɛ–əɔ–u	qómɛsˤ	qəmɔsˤ-ím	qumsˤ-í	'fist'

Unlike all earlier studies, and for reasons outlined in § 2.3, we propose that *the singular form is the input of the paradigm*, from which the plural and the possessive forms are derived. We thus account in this section for two paradigmatic relations: singular-plural (§ 3.2.1) and singular-possessive (§ 3.2.2).

In general, we attribute many of the cases of vowel alternation within these paradigms to the Semitic-type morphology, i.e. the class system (*mishkalim* and *binyanim*), and in a class system, each class is characterized by configurations and their paradigms, where a configuration consists of a prosodic structure, a vocalic pattern and in some cases an affix.

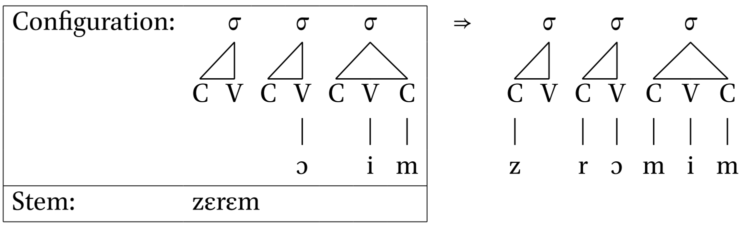
3.2.1 The singular–plural paradigms

Plural forms, as in non-segholates, end in a plural suffix.[9] The base hosting the suffix consists of the configuration CVCɔC, where V is not specified for a particular vowel and thus phonetically interpreted as a schwa (unless affected by a guttural; see § 4). This is consistent with the claim that the phonological representation of a schwa is an empty V-slot, phonetically filled with default features, unless other features override, as in the case of gutturals (Anderson 1982, Clements and Keyser 1983).[10]

As for the prosodic structure and the suffix, segholate plurals (e.g. *zɛ́rɛm—zərɔm-ím* 'downpour/s') could be linearly derived like non-segholates (e.g. *pɔqíð—pəqið-ím* 'commissioner/s'); the base of the plural is prosodically identical to that of the singular, the vowel in the first syllable is reduced to a schwa, and the suffix is the same plural suffix found elsewhere. It is, however, the vowel /ɔ/ in the second syllable of the base that requires to postulate the configuration CVCɔC, since there is no phonological environment for the singular–plural alternation /ɛ/–/ɔ/. Within a rule-based approach (Prince 1975), a segholate-specific vowel replacement rule is proposed, which is basically equivalent to a configuration within the structural approach adopted here. That is, while the prosodic structure of the configuration is predicted based on the prosodic system of the language, the vowel in the second syllable of the plural base must be specific to the category, as much as the vowels in a paradigm of verb class (e.g. *ʃɔvár—ʃovér* 'to break 3MS.SG.PAST—MS.SG.PARTICIPLE').

The plural form is derived via stem modification (Steriade 1988, McCarthy and Prince 1990, Bat-El 1994), whereby the plural configuration is imposed on the singular stem, which is modified accordingly.

(13) Plural formation via stem modification



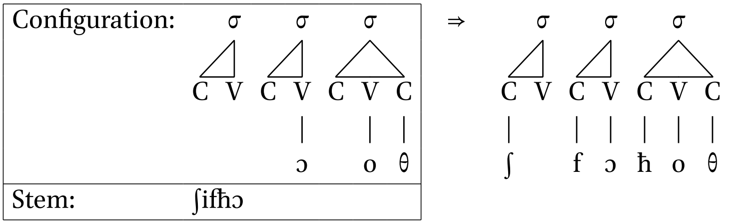
9 The plural suffix in segholates is usually the default *-im*, though there are a few cases with the feminine *-oϑ* (e.g. *nɛ́fɛʃ* 'soul' *ʃɛ́mɛʃ* 'sun') and the dual *-ayim* (e.g. *qɛ́rɛn* 'horn', *rɛ́ɣɛl* 'foot'). This distribution of suffixes is not unique to segholates and is not relevant for the present study.

10 There are two exceptional forms (13f) where /ɔ/ surfaces instead of a schwa: *ʃórɛʃ—ʃɔrɔʃ-ím* 'root' and *qóðɛʃ—qɔðɔʃ-ím* 'sacredness'.

Stem modification predicts that the V-slot in the first syllable will be associated with the singular's /ɛ/ (i.e. **zɛrɔmim*), rather than left empty to be filled by a schwa. However, as is the case with non-segholates, a V-slot in an antepretonic open syllable is left empty when a suffix is added (e.g. *pɔkíð—pəkið-ím* 'commissioner/s'). Thus, in addition to the stem and the configuration, there is a constraint *FULLV, which prohibits a full vowel in an antepretonic open syllable (see Rappaport 1984 and Dresher 2009 for vowel reduction and deletion in BH).

The plural configuration of the segholates is also used by feminine nouns of the configuration CiCCɔ and CaCCɔ. In some cases, such a feminine noun has a masculine segholate counterpart (e.g. feminine *yaldɔ́—yəlɔð-óϑ* 'girl/s'; masculine *yɛ́lɛð* 'child'), but in others it does not (e.g. feminine *ʃifħɔ́—ʃəfɔħ-óϑ* 'maid SG–PL'; **ʃɛ́faħ*).[11]

(14) Plural formation via stem modification: *ʃifħɔ́—ʃəfɔħ-óϑ* 'maid SG–PL'



In principle, any noun can be pluralized with this configuration, but given the Semitic-type nature of the morphological system, which consists of configurations, a noun has to be indexed for this configuration (cf. Arabic broken plural; McCarthy and Prince 1990, Ratcliffe 1998). However, it is not necessary to learn the indexing for each and every noun that takes this plural configuration. Given sufficient input, the learner generalizes that a noun that has a CVCC base in one or more forms in its inflectional paradigm is indexed for this plural form. Segholates have the CVCC base in the possessive (e.g. *yald-i* 'my child'), while CVCCɔ nouns have it in the singular form (e.g. *ʃifħɔ́* 'maid'), assuming the final /ɔ/ is a suffix.

We thus conclude that segholate nouns form their plural with the configuration CVCɔC (to which the plural suffix is attached), and nouns indexed for this configuration have a base CVCC in one or more forms in their paradigm.

11 In order for the noun to be indexed for the plural CVCɔC configuration, all consonants in the CVCC base must be stem consonants. Therefore, *misˁwɔ* 'commandment', where the initial /m/ is a prefix, gets the non-segholate plural *misˁw-óϑ* and not **məsˁɔw-oϑ*. The form *piʃtim* 'linen' is also not a counter example since it is a *pluralia tantum*.

3.2.2 The singular–possessive paradigms

The configuration of the possessive form is CVCC, where V is /i/, /ɔ/, /a/, /ɛ/ or /u/. CiCC is by far the most common configuration, CɔCC is next in line, and CaCC is the least common in the model paradigms; the other two configurations, CɛCC and CuCC, are rare (see Appendix C).

Starting with the prosodic shape of the base, there is no independent synchronic reason, in the sense of McCarthy's (2005) optimal paradigms, why it should be CVCC. Had the possessive suffix been consistently vowel initial, we could have viewed the CVCC base as lexical optimization, since a vowel in a stem final syllable is often deleted when a vowel initial suffix is added, though only in verbs and participles (Bat-El 2008). However, while some possessive suffixes are indeed vowel initial (e.g. *malk-ó* 'his king'), others are consonant initial, where in the latter case a schwa is inserted (e.g. *malk-xa* → *malkəxá* 'your MS.SG king'). In addition, the plural suffix is vowel initial and yet, its base is not CVCC. We thus view the base CVCC as a synchronically arbitrary structure, i.e. a part of a lexically specified configuration of the possessive.

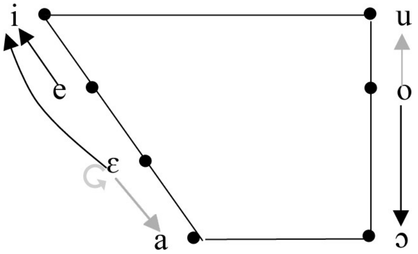
The vocalic pattern is also considered as part of the configuration because it is only partially predicted by the preference for corner vowels, with /i/ in 81% of the unrounded set (in the model paradigms) and /ɔ/ in 87.7% of the rounded sets.

(15) Possessive forms: Distribution

	Set	Singular V_1	Possessive V	N	%
a.	Unrounded	*ɛ, e*	***i***	**163**	**81.5%**
			Exceptions *ɛ* → *a*	34	17%
			Exceptions *ɛ* → *ɛ*	3	1.5%
			Total	200	
b.	Rounded	*o*	***ɔ***	**40**	**87%**
			Exceptions *u*	6	13%
			Total	46	

For the analysis of the vocalic alternations in the singular-possessive paradigms, we assume the vowel chart in (16); see also Appendix A. The assumption that /ɔ/ is phonologically low, like /a/, is supported by the alternation between these two vowels, where /a/ appears in a closed syllable (e.g. *hayyóm* 'the day') and /ɔ/ in an open one (e.g. *hɔʔór* 'the light').[12] The arrows in the chart indicate a singular–possessive relation, where the shade of the arrow reflects the relative distribution of the relation (with grey being the lower distribution).

(16) BH vowel chart



Assuming the above vowel chart, there are two generalizations regarding the preservation of feature values. First, the value of the feature [round] for the vowels /u/, /o/, and /ɔ/ persists throughout the paradigm, suggesting the effect of the faithfulness constraint IDENT[round]. That is, the possessive vowel corresponding to the stem's /ɛ/ and /e/ is [-round] and the one corresponding of the stem's /ɔ/ is [+round]. From this point onward we ignore IDENT[round] and do not consider candidates that violate it.

The second case of feature value preservation is conditional, found in the majority of the paradigms; the stem's [-round] vowels preserve their [-low] feature (i.e. stem /ɛ/ and /e/ correspond to possessive /i/), and the stem's [+round] vowel preserves its [-high] feature (stem /o/ corresponds to possessive /ɔ/). The following IDENT constraints account for these cases of faithfulness.

(17) Conditional feature preservation
a. IDENT[-rnd, -lw]: Stem V[-rnd, -lw] corresponds to possessive V[-rnd, -lw]
b. IDENT[+rnd, -hi]: Stem V[+rnd, -hi] corresponds to possessive V[+rnd, -hi]

Constraint (17a) eliminates the low vowel /a/ from the possessive bases in the [-round] class, and constraint (17b) eliminates the high vowel /u/ from the possessive bases in the [+round] class. This will later require an analysis of exceptions.

12 Note that /ɔ/ has a phonetic space of two vowels (i.e. parallel to the space taken by /a/ and /ɛ/), and therefore it can potentially function as a low vowel for one phenomenon and a mid-vowel for another.

From the remaining vowels in each set, the corner vowels are preferred—/i/ for the unrounded set and /ɔ/ for the rounded set. To manipulate the dichotomy between corner and center vowels (Crosswhite and Jun 2001, Crosswhite 2004, Himmelreich and Bat-El 2018), we use the ranking *CenterV » *CornerV, which eliminates the center [-high, -low] vowels /e/, /o/, and /ɛ/ from the V position in the possessive base. Note that this ranking is relevant only for the possessives, and it could be lexically marked. However, the possessive is also the only form in the segholate paradigms where the first syllable is closed. Thus, we might as well provide a phonological (rather than lexical) specification for these constraints, *CenterV$_{_C]\sigma}$ » *CornerV$_{_C]\sigma}$.

The derivation of the possessive forms is given in (18). Recall that we assume that the base of the possessive is derived from the singular stem, and the prosodic structure of the possessive is part of a lexically specified configuration. The vowel in the possessive thus corresponds to the vowel in the first syllable of the stem.

(18) Possessive forms

	zɛrɛm	*Center	*Corner	Ident[-rnd -lw]	Ident[+rnd -hi]
a. ☞	zirm-i		*		
b.	zerm-i	*!			
c.	zɛrm-i	*!			
d.	zarm-i		*	*!	

	nezɛr	*Center	*Corner	Ident[-rnd -lw]	Ident[+rnd -hi]
a. ☞	nizr-i		*		
b.	nezr-i	*!			
c.	nɛzr-i	*!			
d.	nazr-i		*	*!	

	bosɛm	*Center	*Corner	Ident[-rnd -lw]	Ident[+rnd -hi]
a.	busm-i		*		*!
b.	bosm-i	*!			
c. ☞	bɔsm-i		*		

The IDENT constraints in the above analysis are members in a larger family of constraints. IDENT[-rnd -lw] competes with its counterpart IDENT[-rnd -hi], and IDENT[+rnd -hi] competes with its counterpart and IDENT[+rnd -lw]. These two pairs of constraints have a default ranking (19a) that yields the majority of the forms, and a reverse ranking (19b) for exceptions.

(19) Default and exceptional rankings
a. Default:
IDENT[-rnd -lw] » IDENT[-rnd -hi]—unrounded set (81.5%)
IDENT[+rnd -hi] » IDENT[+rnd -lw]—rounded set (87%)
b. Exception:
IDENT[-rnd -hi] » IDENT[-rnd -lw]—unrounded set (17%)
IDENT[+rnd -lw] » IDENT[+rnd -hi]—rounded set (13%)

The analysis of the exceptions is given in (20) below.

(20) Possessive forms—exceptions
Unrounded set

yɛlɛd	*CENTER	*CORNER	IDENT[-rnd, -hi]	IDENT[-rnd,-lw]
a. yild-i		*	*!	
b. yeld-i	*!			
c. yɛld-i	*!			
d. ☞ yald-i		*		*

Rounded set

qomɛsˤ	*CENTER	*CORNER	IDENT[+rnd, -lw]	IDENT[+rnd -hi]
a. ☞ qumsˤ-i		*		*
b. qomsˤ-i	*!			
c. qɔmsˤ-i		*	*!	

The tableaux in (20) account for 17% of the forms in the unrounded set and 13% of the forms in the rounded set. Not accounted for are the 3 forms (1.5%) with /ɛ/ (instead of /i/) in the unrounded set, which violate the ranking *CENTER » *CORNER.

The above analysis should be further enhanced (in a future study) within a stochastic framework, if we took the statistical tendencies in (21) below, which show that possessive CiCC bases prefer nouns with a coronal in C_1 position, and possessive CaCC bases prefer nouns with a dorsal in C_1 ($\chi^2_{(2)}$=20.4, p<0.001). Assuming that vowels and consonants manipulate the same phonological features (Clements and Hume 1995), the distribution in (21) reflects a tendency for place agreement in the initial CV of the possessive, between the onset and the vowel. With this additional distribution, the error margin of the learner would be negligible.

(21) $_{\omega}$[CV correlation in the possessive forms

	CiCC		CaCC	
Dorsal	19%	31/163	**55.9%**	19/34
Coronal	**59%**	96/163	35.3%	12/34
Labial	22%	36/163	8.8%	3/34

As shown in the following section, the place agreement between C_1 and the following vowel is much stronger when C_1 is a guttural.[13]

4 Segholates with gutturals

Being produced at the lower part of the vocal tract, gutturals (laryngeals and pharyngeals) display a strong affinity with non-high vowels, preferably low vowels (McCarthy 1991, 1994). This affinity is manifested in BH by processes such as vowel lowering (e.g. *hɛħpír* 'displayed shame 3MS.SG'; cf. *hixbíd* 'made heavy 3MS.SG') and low vowel/glide epenthesis (e.g. *pɔruᵃʕ* 'unbind'; cf. *ħɔɣur* 'gird on').

The lowering effect of the gutturals is found in 52.6% (273/519) of the segholates in our database; that is, in 273 of the segholates there is a guttural that affects the paradigm such that at least one of its forms causes the paradigm to deviate from the model paradigms in (1).

13 Following a reviewer's comment, we note that the correspondence between the singular and the possessive forms (or any other form) does not imply the preservation of consonants (or any other property) of the base—it is all a matter of constraint ranking. The fricative in *mélɛx* 'king', for example, is not preserve in *malkí* 'my king', due to the high ranking of the constraint imposing spirantization, crucially above the constraint that requires identity in the value of the feature continuous.

4.1 *Data and generalizations*

As lowering is contingent upon the position of the guttural within the stem, the following discussion considers each position independently.

4.1.1 Gutturals in C_1 position

There are five paradigms with a guttural in C_1. The unique property of these paradigms, when compared with the model paradigms in (1), is that the schwa in the first syllable of the plural form is replaced with a reduced vowel /ă/ or /ɔ̆/, in the unrounded and rounded sets respectively.[14]

(22) Gutturals in C_1 (n=120)

	Vocalic patterns	Singular CVCVC	Plural CVCVC	Possessive CVCC		Distribution n	%
a.	εε–ăɔ–a	ʕέvεð	ʕăvɔð-ím	ʕavd-í	'slave'	43	35.8%
b.	εε–ăɔ–ε	hέvεl	hăvɔl-ím	hεvl-í	'vanity'	4	3.3%
c.	eε–ăɔ–ε	ħélεq	ħălɔq-ím	ħεlq-í	'portion'	25	20.8%
d.	eε–ăɔ–i	ʕémεq	ʕămɔq-ím	ʕimq-í	'vale'	7	5.8%
e.	oε–ɔ̆ɔ–ɔ	ħóðεʃ	ħɔ̆ðɔʃ-ím	ħɔðʃ-í	'month'	41	34.2%

The singular forms in (22) display the same configurations as in the model paradigms, i.e. CεCεC, CeCεC, and CoCεC. In the plural forms, as noted, the vowel in the first syllable is /ă/ in the unrounded set (22a–d) and a short /ɔ̆/ in the rounded set (22e). Note that the replacement of the schwa with a reduced *ħatef* vowel in the environment of gutturals is not unique to segholates (e.g. *ʔɔϑón—ʔăϑon-óϑ* 'female donkey SG-PL'; cf. *lɔʃón—ləʃon-óϑ* 'tongue SG-PL').

The vowel inventory of the possessive forms in (22)—/i/, /a/, /ε/, and /ɔ/—is almost identical to that of the model paradigms (only /u/ is missing, but it is also rare in the model paradigms). Therefore, it seems that a guttural in C_1 position does not affect the vowel in the possessive form. However, a closer look at the distribution of the different vowels in all the segholates, with and with-

14 Reduced vowels are vowels that are not fully specified for segmental features (see § 3.2.1)—the schwa /ə/, and the *ħatef* vowels /ă/, /ε̆/, and /ɔ̆/—where the *ħatef* vowels are phonetically identical to their corresponding full short vowels. The phonological contrast between reduced and full short vowels is not only in feature specification but also in distribution: unlike a short vowel, a reduced vowel cannot appear in a closed syllable nor in word final position.

out gutturals, reveals, again, a strong correlation between C_1 and the following vowel in the possessive form ($\chi^2_{(1)}$=127.7, p<0.001).

(23) $_\omega$[CV correlation in the possessive forms

	[+high]				[-high]						Total
	i		*u*		*ɛ*		*ɔ*		*a*		
Model	163	66.3%	6	2.4%	3	1.2%	40	16.3%	34	13.8%	246
	68.7% (n=169)				31.3% (n=77)						
C_1=G	7	5.8%	–	–	29	24.2%	41	34.2%	43	35.8%	120
	5.8% (n=7)				94.2% (n=113)						

When C_1 is a guttural (G), 94.2% of the possessive forms have a [-high] vowel, out of which 74.3% has a [+low] vowel (/ɔ/ and /a/). Conversely, when C_1 is not a guttural (the model paradigms), 68.7% of the vowels in the possessive forms are [+high]. This is another case of CV agreement (in addition to that in (21)), that has to be taken into consideration within a stochastic approach.

4.1.2. Guttural in C_2 position

The effect of a guttural in C_2 position is found in both the singular and the possessive forms.

(24) Segholate paradigms—Gutturals in C_2 (n=80)

	Vocalic patterns	**Singular CVCVC**	**Plural CVCVC**	**Possessive CVCC**		**Distribution n**	**%**
a.	aa–əɔ–aă	báʕal	bəʕɔl-ím	baʕăl-í	‘owner’	59	73.8%
b.	oa–əɔ–ɔɔ̆	póʕal	pəʕɔl-ím	pɔʕɔ̆l-í	‘work’	21	26.2%

In the singular forms, the vowel following the guttural (V_2) is always /a/ (as opposed to /ɛ/ in the model paradigms), and the one preceding the guttural (V_1) is /a/ in the unrounded set and /o/ in the rounded set.

The possessive forms have only /a/ and /ɔ/ in V_1, corresponding to the unrounded and rounded sets respectively. In addition, since gutturals in BH are banned from coda position, a reduced (*ħatef*) vowel is inserted after the guttural, /ă/ in the unrounded set (*baʕăl-í* 'my owner'; cf. *yald-í* 'my boy') and /ɔ̆/ in the rounded set (*pɔʕɔ̆l-í* 'my work'; cf. *bɔsm-í* 'my spice').

The plural forms adopt the same template as in the model paradigms, which means that the guttural affects the following empty V-slot (i.e. when C_1 is a guttural (22)), but not the preceding one.

4.1.3. Guttural in C_3 position

The effect of a guttural in C_3 is limited to the singular forms, where the vowel preceding the guttural is always /a/ (as opposed to /ɛ/ in the model paradigms).

(25) Segholate paradigms—Gutturals in C_3 (n=73)

	Vocalic patterns	Singular CVCVC	Plural CVCVC	Possessive CVCC		Distribution n	%
a.	ɛa–əɔ–i	mɛ́laħ	məlɔħ-ím	milħ-í	'salt'	45	61.6%
b.	ɛa–əɔ–a	sɛ́laʕ	səlɔʕ-ím	salʕ-í	'cliff'	10	13.7%
c.	ea–əɔ–i	mézaħ	məzɔħ-ím	mizħ-í	'girdle'	6	8.2%
d.	oa–əɔ–ɔ	góvah	gəvɔh-ím	gɔvh-í	'height'	12	16.4%

A guttural in C_3 position does not affect the possessive forms because there is no vowel preceding the guttural and the vowel following the guttural is a suffix. In the plural forms, a guttural in C_3 position is always preceded by a low vowel /ɔ/, which is part of the configuration.

4.2 *Incorporating gutturals into the analysis*

The lowering effect of gutturals is attributed to consonant-vowel assimilation, whereby the vowel is lowered due to the feature [+low] specified in gutturals (McCarthy 1991, 1994). Assimilation is accounted for with the constraint AGREE[F] (Baković 2000), and in the case relevant to the present discussion AGREE[+low]. Forms respecting AGREE[+low] also comply with the ranking *CENTER » *CORNER from the model paradigms (see § 3.2.2), as the low vowels are corner vowels.

As guttural consonants resist alternation, the directionality of assimilation is always from the consonant to the vowel, regardless of their linear order. For this, we assume IDENTC » AGREE[+low] » IDENTV, where the dominance of

IDENTC (where C stands for consonant) ensures the gutturals' faithfulness, while the ranking of IDENTV below AGREE[+low] makes the vowel susceptible to alternation regardless of its position with respect to the guttural; that is, this ranking may also be involved in determining the direction of assimilation. In the following analysis, we ignore IDENTC and the candidates that violate it.

4.2.1. Singular forms

Although directionality is attributed to the interaction of the IDENT constraints with AGREE, it is necessary to split AGREE into two constraints, one referring to a GV sequence and the other to VG (where G stands for a guttural).

(26) AGREE[+low] constraints
  a. AGREEVG: A vowel agrees in the feature [+low] with a *following* guttural
  b. AGREEGV: A vowel agrees in the feature [+low] with a *preceding* guttural

The reason for this complexity is that violation of AGREE is contingent upon the position of the guttural in the stem.

(27) AGREE effects (*na* = not applicable)

G	Singular	AGREEVG	AGREEGV
C_1	ʕέvɛð	*na*	*
	ħélɛq	*na*	*
	hέvɛl	*na*	*
	ʕémɛq	*na*	*
	ħóðɛʃ	*na*	*
C_2	báʕal	√	√
	póʕal	*	√
C_3	mέlaħ	√	*na*
	mézaħ	√	*na*
	góvah	√	*na*

Only the stressed vowel violates AGREE, as expected by the phonetically-based strength hierarchy (§ 2.3), that grants the stressed vowels the power to resist alternation. However, the stressed vowels do not behave alike with respect to the two AGREE constraints. When C_1 is a guttural, all stressed vowels resist lowering, thus violating AGREEGV, but when C_2 is a guttural, only the rounded stressed vowel resists lowering, in violation of AGREEVG.

The different behavior of stressed and unstressed vowels is attributed to the stress-specific IDENT constraint, and thus to the universal ranking IDENTV^{STR} » IDENTV (where the specific constraint outranks the general one; Kiparsky 1973). IDENTV (where V refers to any vowel) is ranked below the two AGREE constraints, because all unstressed vowels undergo lowering. IDENTV^{STR}, however, is ranked between AGREEVG and AGREEGV, because lowering applies in VG sequences (e.g. *báʕal*), but not in GV sequences (e.g. *ʕɛ́vɛð*). In addition, lowering in VG sequences is blocked when the vowel is rounded (e.g. *póʕal*), thus calling for yet another specific IDENT constraint, this time IDENTV [+rnd], which requires stressed rounded vowels in the input to preserve their features in the output. The support for the specification of stress rounded vowel is provided in the following subsection.

The ranking IDENTV[+rnd] » AGREEVG » IDENTV^{STR} » AGREEGV » IDENTV thus accounts for all the singular forms with a guttural. We assume CɛCɛC and CoCɛC stems in the underlying representations, for the unrounded and rounded sets respectively, as these are the most common forms of the model paradigm. Note that the rounded vowel is limited to the first syllable, and therefore only forms with a guttural in C_1 or C_2 are relevant in the rounded set.

(28) Singular forms

a. Unrounded set

		AGRVG	IDENTV^{STR}	AGRGV	IDENTV
C_1=G	**ʕɛ́vɛð**				
	a. ☞ ʕɛ́vɛð			*	
	b. ʕávɛð		*!		*
C_2=G	**bɛ́ʕɛl**				
	a. ☞ báʕal		*		**
	b. báʕɛl		*	*!	*
	c. bɛ́ʕɛl	*!		*	
	d. bɛ́ʕal	*!			*
C_3=G	**mɛ́lɛħ**				
	a. ☞ mɛ́laħ				*
	b. mɛ́lɛħ	*!			

b. Rounded set

C_1=G	**ħóðεʃ**	IDENTV[+rnd]	AGRVG	IDENTV^STR	AGRGV	IDENTV
	a. ☞ ħóðεʃ				*	
	b. ħɔ́ðεʃ	*!		*		*
C_2=G	**póʕεl**					
	a. ☞ póʕal		*			*
	b. póʕεl		*		*!	
	c. pɔ́ʕal	*!		*		**
	d. pɔ́ʕεl	*!		*	*	*

It is important to note that vowel lowering in (28) is a feature-changing process (Kiparsky 1993) that does not involve spreading; that is, the vowel changes the value of [low] from [-] to [+] in order to comply with AGREE. A feature-filling process is introduced in the following section on plural forms, where [+low] spreads from a guttural to an adjacent empty V-slot. As argued below, in the case of feature-changing, AGREE competes with IDENT, but in the case of feature-filling, it competes with *SPREAD.

4.2.2 Plural forms

In the plural forms, AGREEGV is always satisfied, but AGREEVG is violated when C_2 is a guttural. We assume an undominated constraint that ensures the suffix faithfulness and thus limit agreement to the stem. Note that in the plural forms, stress is on the suffix, thus the IDENTV^STR is not relevant. In addition, the low vowel /ɔ/, enforced by the plural configuration CVCɔC, allows the satisfaction of AGREEVG when C_3 is a guttural, and of AGREEGV when C_2 is a guttural.

(29) Plural: AGREE effects

G	Plural	AGREEVG	AGREEGV
C_1	ʕăvɔð-ím	*na*	√
	ħɔ̆ðɔʃ-ím	*na*	√
C_2	bəʕɔl-ím	*	√
C_3	məlɔħ-ím	√	*na*

What remains to be attended to is the quality of the vowel in the first syllable, which stands in an antepretonic position. Recall from § 3.2.1 that an open syllable in an antepretoinc position cannot host a full vowel, and therefore a schwa replaces the stem vowel, in segholates and non-segholates alike.

Following previous studies (Anderson 1982, Clements and Keyser 1983), we assume that a schwa is an empty V-slot, and the constraint that enforces schwa, *FullV, prohibits a V-slot from licensing features in an antepretonic position.

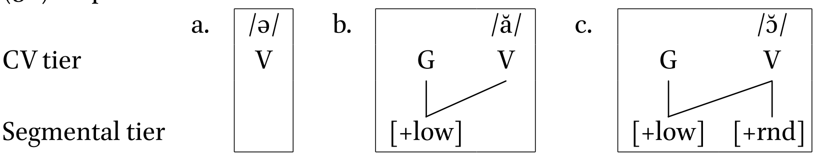
In the environment of a guttural, the schwa in the plural forms takes a different color, represented by the low reduced vowels /ă/ and /ɔ̆/, but only when C_1 is a guttural (30a); when C_2 is a guttural (30b), a schwa surfaces as in a guttural-free environment (30c, d).

(30) Plural forms: Vowel in an antepretonic syllable

	Singular CVCVC	Plural CVCVC
a. C_1=G	ʕɛ́vɛð	ʕăvɔð-ím
	ħóðɛʃ	ħɔ̆ðɔʃ-ím
b. C_2=G	báʕal	bəʕɔl-ím
	póʕal	pəʕɔl-ím
c. C_3=G	sɛ́laʕ	səlɔʕ-ím
	góvah	gəvɔh-ím
d. Model	zɛ́rɛm	zərɔm-ím
	bósɛm	bəsɔm-ím

As shown below, the vowel /ă/ (31b) respects *FullV, just like /ə/ (31a), because it does not license any feature; the feature [+low] in /ă/ is licensed by G (the guttural), from which it spreads to the V-slot, in violation of the constraint *Spread.[15]

(31) Representation of reduced vowels



15 This is the same structure as in the case of homorganic codas, which respect the Coda Condition since their place feature is licensed by the following onset (Itô 1986, 1989).

Unlike /ə/ and /ă/, which respect *FULLV, the vowel /ɔ̆/ violates it due to the preservation of the stem's [+round]. We assume the constraint ranking MAX[+rnd] » *FULLV, where the former prohibits deleting of the feature [+round].[16]

(32) Selecting the reduced vowel (plural with C_1=G)

	ʕɛ́vɛð	MAX[+rnd]	AGRGV	*FULLV	*SPREAD
a. ☞	ʕăvɔð-ím				*
b.	ʕəvɔð-ím		*!		
c.	ʕavɔð-ím			*!	
	ħóðɛʃ				
a. ☞	ħɔ̆ðɔʃ-ím				*
b.	ħəðɔʃ-ím	*!	*		
c.	ħoðɔʃ-ím		*!	*	
d.	ħăðɔʃ-ím	*!			*

Notice, however, that [+low] spreads from a guttural to a following vowel (e.g. *ʕăvɔðím*), but not to a preceding vowel (e.g. *bəʕɔlím*). In order to address this contrast, we split *SPREAD into two constraints, specified for different directionalities.

(33) *SPREAD
a. *SPREADLR: A feature does not spread from *left-to-right*
b. *SPREADRL: A feature does not spread from *right-to-left*

Each of the *SPREAD constraints competes with one of the AGREE constraints, as AGREE requires spreading and *SPREAD prohibits it. The ranking *SPREADRL » AGREEVG blocks lowering in a VG sequence and the ranking AGREEGV » *SPREADLR imposes spreading in a GV sequence. Recall

16 Both IDENTV[+rnd] and MAX[+rnd] reflect the preservation of the marked (de Lacy 2006). However, IDENTV[+rnd] preserves all the features of the vowel containing the marked feature [+round], thus preserving the post-guttural mid vowel /o/ (e.g. *ħóðɛʃ*). MAX[+rnd], on the other hand, preserves only the feature [+round], thus allowing lowering and reduction (e.g. *ħɔ̆ðɔʃ-ím*).

that spreading is possible only when the V-slot is empty, i.e. when *FullV is respected.

(34) Guttural agreement in plural forms

		*SpreadRL	AgreeVG	AgreeGV	*SpreadLR
C_1=G	**ʕέvɛð**				
	a. ☞ ʕăvɔð-ím				*
	b. ʕəvɔð-ím			*!	
C_2=G	**báʕal**				
	a. băʕɔl-ím	*!			
	b. ☞ bəʕɔl-ím		*		

The ranking AgreeVG » AgreeGV was established earlier, in the analysis of the singular forms, where a GV sequences does not always agree in the feature [+low] (e.g. *ʕέvɛð*), while a VG sequence always does (e.g. *báʕal*, *mέlaħ*). Recall that we distinguish between feature filling and feature changing lowering, and thus assume that the low vowels in the singular forms do not involve feature spreading but rather lowering, and therefore the constraint *Spread is not violated. Spreading affects only empty positions, and therefore, it applies in the plural forms, where the first V-slot is empty due to *FullV. Agree is thus respected regardless of the source of the feature [+low], whether the low vowel is part of the configuration (e.g. *bəʕɔl-ím* 'owners'), derived by feature change (e.g. *báʕal* 'owner') or feature spread (e.g. *ʕăvɔð-ím* 'slaves').

(35) Constraint ranking for gutturals

*SpreadRL (» AgreeVG); Max [+rnd] » *FullV; Max [+rnd] » AgreeGV

IdentV[+rnd] » AgreeVG » IdentV^{STR} » AgreeGV » IdentV

AgreeGV » *SpreadLR

The summary of the constraint ranking of gutturals reveals three active families of constraints (see Appendix E): Ident, Agree[+low], and *Spread.

4.2.3 Possessive forms

As in the model paradigms, the possessive forms fit into the configuration CVCC, where V is in most cases /i/, but other vowels may appear as well (see Appendices B and C).

(36) Possessive: AGREE effects

G	Possessive	AGREEVG	AGREEGV	cf. guttural-free
C_1	ʕavd-í	*na*	√	yald-í
	ħɛlq-í	*na*	*	nɛxd-í
	ʕimq-í	*na*	*	zirm-í
	ħɔðʃ-í	*na*	√	bɔsm-í
C_2	baʕăl-í	√	√	yald-í
	pɔʕɔ̆l-í	√	√	bɔsm-í
C_3	milħ-í	*na*	*na*	zirm-í
	salʕ-í	*na*	*na*	yald-í
	gɔvh-í	*na*	*na*	bɔsm-í

In the absence of guttural effect in possessive forms with gutturals in C_1 position, the constraints responsible for the vowel in the possessive forms, i.e. *CENTER » *CORNER » IDENT[-rnd -lw] » IDENT[-rnd -hi] (see (19)), are ranked above the AGREE constraints responsible for the guttural effect.

In addition, as gutturals in BH are prohibited from coda position, a V-slot is inserted to rescue the constraint $*G]_\sigma$, responsible for this prohibition. The inserted empty V-slot copies its features from the base vowel, not from the guttural, as evident by the spreading of the [+round] in *pɔʕɔ̆l-í*. As the epenthetic V gets its features via spreading, it is a phonologically reduced (*ħatef*) vowel, i.e. a vowel that does not have its own features. In this state of affairs, the ranking of $*G]_\sigma$ above DEPμ ensures epenthesis of a prosodic position, and the ranking of a general AGREE (not specified for gutturals) above *SPREADLR and below *SPREADRL ensures the left-to-right V-to-V spreading.

5 Concluding remarks

In this paper, we proposed a novel analysis of the morpho-phonological alternation in BH's segholate paradigms, addressing the alternation in the vocalic pattern and prosodic structure, and the unique stress pattern in the singular forms. The motivation for our proposal was that all previous analyses do not comply with universal typology, according to which stressed vowels are strong, thus resist alternation, and epenthetic vowels are weak, by virtue of being featureless, thus cannot trigger segmental alternation.

The novelty of our analysis begins with the claim that the stem of the paradigm is the surface singular form, and not the base of the possessive form as proposed in other analyses. This alone eliminates the fault of earlier analyses, i.e. alternation in stressed vowels triggered by an epenthetic vowel.

In our analysis, the weakness of an epenthetic vowel, like a reduced vowel (schwa and *ħatef* vowels), is structurally expressed by a V-slot without its own features, and the strength of the stressed vowel is accounted for with the constraint IDENTV^{STR}.

Finally, our analysis does away with the opacity encountered in segholates with a final guttural, such as /diʃʔ/ → *dέʃɛ* 'grass' (McCarthy 1999), where the epenthetic /ɛ/ is not phonologically motivated after the deletion of the final glottal. Under our analysis, the /ɛ/ is not epenthetic (i.e. the input is /dɛʃɛʔ/) and therefore the deletion of the final glottal does not interact with any other process.

The simple paradigmatic relation proposed in our analysis, is not exceptions-free, and it actually has more irregular forms than analyses with a CVCC input (18 % vs. 11 % respectively in the model paradigms, see Appendix D). Nevertheless, we contend that this difference is not high enough to suppress a natural system, as our analysis better fits with universal tendencies than earlier analyses.

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Appendix A: Segmental inventory

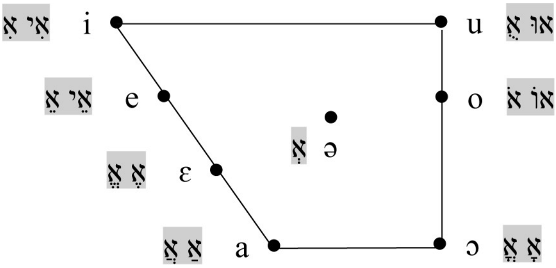

FIGURE A.1 Biblical Hebrew (Tiberain script) vowels with corresponding graphemes.
According to the quantitative theory the different vowel graphemes correspond to moraic structure, where a reduced vowel is a monomoraic vowel without inherent segmental content; it gets it from a neighboring segment (usually a guttural), or a schwa (אְ) by default.

אִי, אִ	i		
אוּ, אֻ	u		
אֵי, אֵ	e		
אוֹ, אֹ	o		
אֶ	ɛ	אֱ	ɛ̆
אָ	ɔ	אֳ	ɔ̆
אַ	a	אֲ	ă
		אְ	ə

FIGURE A.2
The vowels on the left column are full vowels, while those on the right are the schwa and its allophones in the environment of gutturals (see § 4).

TABLE A.1 Biblical Hebrew consonants with corresponding graphemes

	Bilabial	Labio-dental	Interdental	Alveolar	Post-alveolar	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p פּ, b בּ			t תּ, tˤ ט, d דּ			k כּ, g גּ	q ק		ʔ א
Fricative		f פ, v ב	θ ת, ð ד	s ס, שׂ, sˤ צ, z ז	ʃ שׁ		x כ, ɣ ג		ħ ח, ʕ ע	h ה
Nasal	m מ			n נ						
Liquid				l ל				r ר		
Glide	w ו					y י				

The chart includes the non-phonemic labio-dental, interdental, and velar fricatives, which arise due to post-vocalic spirantization (Idsardi 1998): *p→f, b→v, t→ϑ, d→ð, k→x, g→ɣ*.

The place of articulation of the rhotic is controversial (Khan 1995, 2016; see however Revell 1981), with a possible uvular /ʀ/ phoneme and a coronal /r/ allophone in the environment of a coronal (adjacent or within the same syllable). As the allophone does not have grapheme, we use the generic /r/ in the transcription.

Appendix B: Segholate paradigms (n=519)

TABLE B.1 Model (guttural-free) paradigms (n=246)

	Vocalic patterns	Singular CVCVC	Plural CVCVC	Possessive CVCC		Distribution n	% out of all Segholates
a.	εε–əɔ–i	zέrεm	zərɔm-ím	zirm-í	'downpour'	138	26.6%
b.	εε–əɔ–a	yέlεð	yəlɔð-ím	yald-í	'child'	34	6.6%
c.	εε–əɔ–ε	nέxεð	nəxɔð-ím	nεxd-í	'progeny'	3	0.6%
d.	eε–əɔ–i	nézεr	nəzɔr-ím	nizr-í	'crown'	25	4.8%
e.	oε–əɔ–ɔ	bósεm	bəsɔm-ím	bɔsm-í	'spice'	38	7.3%
f.	oε–ɔɔ–ɔ	ʃórεʃ	ʃɔrɔʃ-ím	ʃɔrʃ-í	'root'	2	0.4%
g.	oε–əɔ–u	qómεsˤ	qəmɔsˤ-ím	qumsˤ-í	'fist'	6	1.2%

TABLE B.2 Guttural paradigms (n=273)

Guttural position	Vocalic patterns	Singular CVCVC	Plural CVCVC	Possessive CVCC		Distribution n	% out of all Segholates
C_1 n=120	εε–ăɔ–a	ʕέvεð	ʕăvɔð-ím	ʕavd-í	'slave'	43	8.3%
	εε–ăɔ–ε	hέvεl	hăvɔl-ím	hεvl-í	'vanity'	4	0.8%
	eε–ăɔ–ε	ħélεq	ħălɔq-ím	ħεlq-í	'portion'	25	4.8%
	eε–ăɔ–i	ʕémεq	ʕămɔq-ím	ʕimq-í	'vale'	7	1.4%
	oε–ɔ̆ɔ–ɔ	ħóðεʃ	ħɔ̆ðɔʃ-ím	ħɔðʃ-í	'month'	41	7.9%
C_2 n=80	aa–əɔ–aă	báʕal	bəʕɔl-ím	baʕăl-í	'owner'	59	11.4%
	oa–əɔ–ɔɔ̆	póʕal	pəʕɔl-ím	pɔʕɔ̆l-í	'work'	21	4.1%
C_3 n=73	εa–əɔ–i	mélaħ	məlɔħ-ím	milħ-í	'salt'	45	8.7%
	εa–əɔ–a	sέlaʕ	səlɔʕ-ím	salʕ-í	'cliff'	10	1.9%
	ea–əɔ–i	mézaħ	məzɔħ-ím	mizħ-í	'girdle'	6	1.2%
	oa–əɔ–ɔ	góvah	gəvɔh-ím	gɔvh-í	'height'	12	2.3%

Our database does not include CV_1CV_2 nouns with penultimate stress, where V_2 is [+high]—CέCi (n=6), CóCi (n=13), Cɔ́Cu (n=2), and CóCu (n=2). The final vowel is, at least historically, a glide, but the transcription of such forms is inconsistent (e.g. *mέri* vs. *mərí* 'rebellion', *yófi* vs. *yəfí* 'beauty') where one version is not a segholate. We also excluded *mɔ́wεϑ* 'death' and *záyiϑ* 'olive' for their unique paradigms.

Appendix C: Distribution of vocalic patterns (VP)

TABLE C.1 Singular (CVCVC) (n=519)

VP	Total		Model	Guttural
ɛɛ	222	42.8%	175	47
eɛ	57	11.0%	25	32
oɛ	87	16.8%	46	41
ɛa	55	10.6%	0	55
aa	59	11.4%	0	59
oa	33	6.4%	0	33
ea	6	1.2%	0	6

TABLE C.2 Possessive (CVCC) (n=519)

VP	Total		Model	Guttural
i	221	42.6%	163	58
u	6	1.2%	6	0
ɛ	32	6.2%	3	29
ɔ	114	22.0%	40	74
a	146	28.1%	34	112

Appendix D: Distribution of irregular forms (regardless of gutturals)

Our analysis						Previous analyses					
Possessive:	$V_{[-back]}$	Regular	*i*			Singular:	$V_{1[-back]}$	Regular	*ɛ*		
		Irregular	*a*	(1b)	n=34			Irregular	*e*	(1d)	n=25
		Irregular	*ɛ*	(1c)	n=3						
	$V_{[+back]}$	Regular	*ɔ*								
		Irregular	*u*	(1g)	n=6						
Plural:	V_1	Regular	*ə*			Plural:	V_1	Regular	*ə*		
		Irregular	*ɔ*	(1f)	n=2			Irregular	*ɔ*	(1f)	n=2
		Total: 45/246—18.3%						Total: 27/246—11%			

Appendix E: Constraints (M = markedness, F = faithfulness)

$C1_M$		W-TO-S	A heavy syllable is stressed
$C2_M$		W-BY-P	A coda is moraic
$C3_F$	DEPμ	DEPμ	Do not add a mora
		DEPμ[SEGOL]	Do not add a mora *in the segholate class*
$C4_F$	$MAX_{[F]}$	MAX[+rnd]	Do not delete the feature [+round]
$C5_F$	$IDENT_{[F]}$	IDENT[-rnd -lw]	Stem V[-rnd, -lw] corresponds to possessive V[-rnd, -lw]
		IDENT[+rnd -hi]	Stem V[+rnd, -hi] corresponds to possessive V[+rnd, -hi]
		IDENT[-rnd -hi]	Stem V[-rnd, -hi] corresponds to possessive V[-rnd, -hi]
		IDENT[+rnd -lw]	Stem V[+rnd, -lw] corresponds to possessive V[+rnd, -lw]
		IDENT[+rnd]	Stem V[αrnd] corresponds to possessive V[αrnd]
$C6_F$	IDENTV	IDENTV	Corresponding vowels are identical
		IDENTV[STR]	Corresponding *stressed* vowels are identical
		IDENTV[+rnd]	Corresponding *rounded* vowels are identical
$C7_F$		IDENTC	Corresponding consonants are identical
$C8_M$	*V	*CENTERV	*Center* vowels are prohibited
		*CORNERV	*Corner* vowels are prohibited
		$*CENTERV_{\_C[\sigma}$	*Center* vowels in closed syllables are prohibited
		$*CORNERV_{\_C[\sigma}$	*Corner* vowels in closed syllables are prohibited
		*FULLV	A V-slot in antepretonic position is empty
$C9_M$		$*G]_\sigma$	No guttural in coda position

$C10_M$	AGREE[+low]	AGREEVG	A vowel agrees in the feature [+low] with a *following* guttural
		AGREEGV	A vowel agrees in the feature [+low] with a *preceding* guttural
$C11_M$	*SPREAD	*SPREADLR	A feature does not spread from *left-to-right*
		*SPREADRL	A feature does not spread from *right-to-left*