DZONGKHA NUMBER SYSTEMS

Martine Mazaudon

CNRS, Paris

INTRODUCTION

Central and Written Tibetan are known to have a purely decimal number system, without any of the traces of a quinary or vigesimal system which can be found scattered in other Tibeto-Burman languages. Their close relative, Dzongkha, the national language of Bhutan, has preserved, alongside a decimal system copied from Tibetan, a complete vigesimal system with lexical names for the bases up to 160 000 (20^4). Another Bodish language, Tamang, spoken in Central Nepal, has a less extensive vigesimal system, which is the only number system of that language. I suspect that further research would reveal similar systems in other languages of that group, including some dialects of Tibetan.

From the typological point of view, three number systems co-exist in Dzongkha: 1) a decimal-vigesimal system whose main features are a) the use of addition, multiplication and division (fractions) in the building of numbers, b) the use of 'over-counting' (expressing the number in relation to the higher limit of the interval which contains it, but reckoning it from the lower limit), c) the expression 'on the surface' of the base of rank zero (the

unit); 2) a decimal system used in formal speech, and probably borrowed; and 3) a system of grouping by pairs.

I. NUMBER NAMES FROM 1 TO 19

Up to 20, Dzongkha has a single set of number words.[1]

Table 1 : Number names from 1 to 19

Form[2]	*Structure*	*Meaning*
ci:		1
'ɲi:		2
sum		3
ʑi/ʑẹ		4
'ŋa		5
ɖhu:		6
dyn		7
ge:		8
gu:		9
cuthãm/cu	10 (full)	10
cuci	10.1	11
cuɲi	10.2	12
cusu/cusum	10.3	13
cyʑi	10.4	14
ceŋa	10.5	15
cuɖu/curu	10.6	16
cupdỹ	10.7	17
copge/couge	10.8	18
cygu	10.9	19

As can be seen from Table 1, the organizing principle is purely decimal : Numbers from 1 to 10 have unanalysable names, and numbers from 11 to 19 are formed by adding to the root 10 the names of the units from 1 to 9. We find no trace here of the PTB root *s-nis '7', whose etymological connection with PTB *(g-)nis '2' betrays an old quinary system in PTB.This is somewhat surprising since other Bodish languages, such as Tamang with *hnis, or Dungkarpa (Eastern Bhutan) with nis 7, have kept this root, pointing to the familiar quinary-vigesimal system as a possible ancestor to their present day decimal-vigesimal systems. But a survey of vigesimal systems such as those in Dixon and Kroeber or in Menninger reveals that the decimal-vigesimal pattern is at least as frequent as the quinary-vigesimal.

Under 20, Dzongkha is in no way vigesimal either, since all number names from 11 on are clearly compounds, at least etymologically. In this respect Dzongkha is not exceptional, since no purely vigesimal system (that is using a number sequence of the 1 2 3 4 5 6 7 8 9 A B C D E F G H I J 10 type) has yet been reported. It seems that the 20 gradation is always interrupted by a smaller gradation by 5s or by 10s (Menninger, 56sqq.).

II. TWENTY

With "twenty", Dzongkha starts to differentiate between a decimal and a vigesimal method of reckoning. In the decimal system, "twenty" is /ɲiɕu/, etymologically |2.10|, but strongly amalgamated. The root '2' has lost its high tone,[3] and the root 10 is weakened to /ɕu/ , whereas in the names of the other tens the multiplier retains its "strong" form (corresponding to an old prefixed form as we will see below), and '10' is either /cu/ or /pcu/. The form for '20' and all the other forms of the decimal system are very similar to the Central and Written Tibetan forms, and are in my opinion either straight borrowings or calques from the more prestigious Tibetan norm.

In the vigesimal system, "twenty" is /khe/, an unanalysable morpheme, always accompanied by a multiplicator, including 'one', so that '20' is actually /khe ci:/, |20.1|. The internal syntax of '20' and of all the multiples of a base in the vigesimal system is multiplicand + multiplier, which is in agreement with the general word order of Dzongkha: Noun + Quantifier. The forms are not amalgamated, and their internal syntax is transparent.

Conversely, number names in the decimal system follow the order multiplier + multiplicand, as in /ɲiɕu/, and are more or less amalgamated. So much so that Dzongkha has employed the word /ɲiɕu/ twice, once in the decimal system to mean '20', and once in the

vigesimal system to mean '400' that is 20^2. There is no resulting ambiguity, since 20^2 has to be used with the multiplier 'one': hence /ɲiɋu ci:/ is 400, while /ɲiɋu/ is 20!

III. THE DECIMAL SYSTEM

a. The tens

The names of the tens are formed with the name of the corresponding unit followed by '10'. They are not used as building blocks for the names of intermediate numbers.

Table 2: The tens in the decimal system

Form	*Structure*	*Meaning*
ɲiɋu	(2.10)	20
sum-cu	3.10	30
ʐi-p-cu[4]	4.10	40
'ŋa-p-cu[4]	5.10	50
ɖhuk-cu	6.10	60
ɖyn-cu	7.10	70
ge-p-cu[4]	8.10	80
gu-p-cu[4]	9.10	90

b. Intermediate Numbers

Here again the principle is the same as in WT: the name of the unit is added to a reduced form of the name of the ten. Thus the number names are not built by a transparent arithmetical

operation using the names of the levels of rank 1 (the multiples of 10 below the next power of 10).

From 21 to 29, two different roots for '20' are used depending on the object counted: dates use /ɲer/, while everything else uses /tsa/. In modern Dzongkha, these two bound forms are understood as meaning '20' in compound number names. Etymologically, /ɲer/ is probably connected to '2', but /tsa/ is clearly the old connective particle WT rtsa used in WT to connect the tens to the units e.g. nyi-shu-rtsa-gcig |(2.10) and 1|, '21' (Jaschke). The use of the short forms rtsa-gcig, rtsa-gnyis, etc. is also attested in WT, but the meaning shift is not completed, so that ambiguity may arise between such numbers as 1002, and 1022, depending on whether rtsa is understood as 'and' or as '20'. In Dzongkha the shift is completed, and another connective, /dã/~/da/ (WT dang) is used. The long forms are not used in Dzongkha. Forms in /ɲer/ are also found in WT, but they are apparently not reserved to reckoning dates, as they are in Dzongkha.

Table 3: Decimal number names from 21 to 29

Form		Structure	Meaning
Dates	*Other*		
ɲer-ci	tsa-ci	20.1 / and-1	21
ɲer-ɲi	tsa-ɲi	20.2 / and-2	22
ɲer-sum	tsa-sum	20.3 / and-3	23

Form		Structure	Meaning
Dates	Other		
ɲer-ʑi	tsa-ʑi	20.4 / and-4	24
ɲer-ŋa	tsa-ŋa	20.5 / and-5	25
ɲer-ɖu	tsa-ɖu	20.6 / and-6	26
ɲer-dyn	tsa-dyn	20.7 / and-7	27
ɲer-ge	tsa-ge	20.8 / and-8	28
ɲer-gu	tsa-gu	20.9 / and-9	29

From 31 on, only one set of number names is used. These are compound words made up of a variant of the name of the ten followed by the name of the unit. Such compact forms are also used in Written and Central Tibetan concurrently with analytical forms like sum-cu-rtsa-gcig |(3.10)-and-1|, '31'. For Western Tibetan *Jaschke quotes complex redundant forms such as /ɲi-ʂu-ɲer-gcig/* |(2.10)-20-1|, '21', /ʑip-cu-ʑe-cig/ |(4.10)-40-1|, '41', etc., forms which, according to Roerich and Lhalungpa (46sqq.)are also found in CT. Neither type of analytical form is found in Dzongkha.

Table 4: Decimal numbers from 31 to 99

Form[5]	Structure	Meaning
sum-cu	3.10	30
so-ci	30.1	31
so-ɲi	30.2	32
so-sum	30.3	33
so-ʑi	30.4	34

Form	Structure	Meaning
so-ŋa	30.5	35
so-ɖu	30.6	36
so-dyn	30.7	37
so-ge	30.8	38
so-gu	30.9	39
ʒipcu	4.10	40
ʒhe-ci	40.1	41
ʒhe-ɲi	40.2	42
ʒhe-sum	40.3	43
ʒhe-ʒi	40.4	44
etc.		
'ŋapcu	5.10	50
ŋa-ci	50.1	51
ŋa-ɲi	50.2	52
etc.		
ɖhukcu	6.10	60
re-ci	60.1	61
re-ɲi	60.2	62
etc.		
dyncu	7.10	70
dhøn-ci	70.1	71
dnøn-ɲi	70.2	72

	Form	*Structure*	*Meaning*
	dhøn-sum	70.3	73
	etc.		
gepcu		8.10	80
	ʒa-ci	80.1	81
	ʒa-ɲi	80.2	82
	etc.		
gupcu		9.10	90
	gho-ci	90.1	91
	gho-ɲi	90.2	92
	etc.		

c. Hundreds and thousands and the higher powers of 10

10^2 is /ʒa/ (WT brgya), used as /ʒa-thampa/ '100 full' as the platform reached after enumerating the tens or the units, and as /cik-ʒa/ '1-100' as the first in the enumeration of the hundreds. /ʒa-thampa/ is probably a direct loan from Tibetan, since the Dzongkha form of 'full' would be the contracted form /thãm/ as in 'ten'.

10^3 is /toŋ/ or /tõ-/, used as /cik-toŋ/, '1-1000', or in a nominalized form with the suffix /ʈha/ (WT phrag, 'interval') which is then counted according to the usual Dzongkha construction Noun + Quantifier as /tõ-ʈha ci:/, $|10^3$-group 1$|$.

Table 5: Hundreds and thousands in the decimal system

Form	*Structure*	*Meaning*	*Form*	*Structure*	*Meaning*
cik-ʒa[6]	1.100	100	cik-toŋ[6]	1.10^3	1000
ɲi-ʒa	2.100	200	ɲi-toŋ	2.10^3	2000
sum-ʒa	3.100	300	sum-toŋ	3.10^3	3000
ʑip-ʒa	4.100	400	ʑip-toŋ	4.10^3	4000
'ŋap-ʒa	5.100	500	'ŋap-toŋ	5.10^3	5000
ɖhuk-ʒa	6.100	600	ɖhuk-toŋ	6.10^3	6000
dyn-ʒa	7.100	700	dyn-toŋ	7.10^3	7000
gep-ʒa	8.100	800	gep-toŋ	8.10^3	8000
gup-ʒa	9.100	900	gup-toŋ	9.10^3	9000

The hundreds and the thousands are, like the tens, made up of the independent form of the unit, used as multiplier, followed by the appropriate power of ten. Note that 'one'/cik/ is not aspirated in composition while it is in WT (chig-brgya, '100'). '2' as a multiplier is on the low tone as in /ɲiʨu/, '20' (on which see note 3).

The names of the higher powers of 10 are all borrowed from Central Tibetan, as evidenced by the use of the aspirated form of the multiplier 'one' in 10^4, and by the treatment of by as /ʒh/ in 10^7 (WT bye-ba), where the normal Dz reflex should be /bʒh/.

Table 6: Higher powers of 10

Form	*Structure*	*Meaning*
chik-ʈhi	1.10^4	10.000
bum	10^5	100.000, 1 lakh
saja	10^6	1.000.000
ɟhewa	10^7	10.000.000, 100 lakh
dhuɲchur	10^8	100.000.000

IV. THE VIGESIMAL SYSTEM

The decimal system we have just seen is used in formal speech. It is the set of forms that was first given by the informants as the more appropriate to be taught to foreigners. In everyday life,[7] the Bhutanese use a vigesimal system, which, above the fundamental base 20, is not interrupted by any other base: the borrowed decimal bases have not penetrated the vigesimal system.

a. The fundamental base 20 and the bases of higher order (powers of 20)

Up to the fourth power of the fundamental base 20, that is 160 000, Dzongkha has names for the powers of 20, which are not analysable into arithmetical operations on smaller numbers. Thus:

1 khe = 20

1 ɲiɕu = 20 khe

1 khecʰe = 20 ɲiɕu

1 jã:che = 20 khecʰe

Counting the bases:

Multiples of the bases in the vigesimal system are formed by a noun phrase construction using the set of numbers of 1 to 19 as multipliers, in the order multiplicand + multiplier.

Table 7: The bases and their multiples in the vigesimal system

Form	*Structure*	*Meaning*
khe ci:	20.1	20
khe 'ɲi:	20.2	40
khe sum:	20.3	60
etc.		
khe cuthãm*	20.10	200
etc.		
khe ceŋa	20.15	300
etc.		
ɲiɕu ci:	20^2.1	400
ɲiɕu 'ɲi:	20^2.2	800
etc.		

[*/khe cu/ can also be used if another number follows.]

Form	*Structure*	*Meaning*
ɲiçu cuthãm	20^2.10	4 000
etc.		
khe-chø ci: /khe-che ci:	20^3.1	8 000
khe-che 'ɲi	20^3.2	16 000
etc.		
jã:-che ci:	20^4.1	160 000
etc.		

The names of the bases:

Twenty, /khe/,[8] is originally a measure name,[9] like its WT cognate khal, for which Jaschke gives two main meanings 1)"burden, load" and 2)"bushel, a dry measure = 20 bre" (the measure word meaning), "therefore [...] a score or twenty things of the same kind" (the derived grouping and number meaning).

In Tamang '20' is /^{4}pokal/,[10] a word formed from two synonymous roots for the bushel : cf WT khal just mentioned and WT 'bo (Dz /ba/), also a measure of volume worth 20 bre (Dz /bɟhe/). Neither in Dzongkha /khe/ nor in Tamang /^{4}pokal/ is there any trace nowadays of the original use of the word as a measure : only the abstract meaning of '20' is found.

The Chepang language of Western Nepal has a duodecimal number system. In that language it is 12, the fundamental base of the Chepang number system, which is cognate to the Bodic 20 with a form /haale/,[11] This shift in value is easily understood if the basic meaning of the word is "the first grouping on which the numbers higher up will be built up", which is another way to say "the fundamental base of the number system, whatever that system may be".

Four-hundred, /ɲiɋu/, obviously borrowed from a different system where it meant '20' (2 x 10), is one more example of the easy shift of one base name to another, this time to the base of the next higher rank.

Eight-thousand (20^3) is /khe-che/ or /khe-chø/ (WT che-ba 'large'), and is etymologically 'a large twenty'. This formation is reminiscent of French *une grosse*, which is 144, or 12 dozens, that is 'a large dozen'. Inside abstract and well integrated number systems, etymology often reveals such an origin for the names of rather large numbers: Sanskrit padma is 10^{10}, maha-padma is 10^{11}; French and Romance million, milli-one is a big mille, a large thousand. One hypothesis about 'thousand' itself derives it from Gothic þusundi, cf. Old Norse þushundrad, and sees in þus the reflex of the IE root *tu 'strong, fat'; hence thousand would be the 'strong hundred'. (More examples from Hottentot, Gypsy, Sumerian,

etc.,can be found in Menninger, 47, 132.)

The etymology of the next base, 20^4 /jã:che/ is obscure; but the morpheme /che/ 'large' is also present.

Menninger uses features like those exhibited by the Dzongkha base names--name of the fundamental base meaning a measure or bundle of some kind, shift of one base name to another base, formation of the names of bases of higher rank by qualifying a lower base with the word 'large'--as arguments to show that the set of bases of a number system originates as a hierarchically ordered system of groupings. This means, for Dzongkha, that 400 is conceptually reached not by adding 1 to 399, but by counting 20 groups of 20 units each.

Greenberg's (1978) second generalization about numeral systems: "Every number n ($0 < n < L$) [where L is the largest number in that system] can be expressed as part of the numerical system in any language." is certainly true for the Dzongkha vigesimal system. Even so the set of bases have a different status from other numbers, and several different principles for number building are used in the system as we shall see now with the expression of intermediate numbers. The basic structure of the system is not constructed by a 1 by 1 progression.

b. Intermediate numbers 1 : fractions and overcounting

If a number equals a multiple of a base plus a half or three-quarters of that base value, a complex expression using the morphemes 1/2 and 3/4 will be used, and the point of reference will be the next higher multiple of the base, what Menninger calls *over-counting*.

Table 8: Numbers with fractional components in the vigesimal system

Form	*Structure*	*Meaning*
khe pɟhe-da 'ɲi	20 1/2-& 2	20 x (1+1/2)=30
khe ko-da 'ɲi	20 3/4-& 2	20 x (1+3/4)=35
khe pɟhe-da sum	20 1/2-& 3	20 x (2+1/2)=50
khe ko-da sum	20 3/4-& 3	20 x (2+3/4)=55
...		
ɲiɕu pɟhe-da 'ɲi	20^2 1/2-& 2	400 x (1+1/2)=600
ɲiɕu ko-da 'ɲi	20^2 3/4-& 2	400 x (1+3/4)=700
ɲiɕu pɟhe-da sum	20^2 1/2-& 3	400 x (2+1/2)=1000
ɲiɕu ko-da sum	20^2 3/4-& 3	400 x (2+3/4)=1100
...		

The same connector /da/ is used here as in non-fractional numbers e.g. /khe ci: da ci:/, |20-1-and-1|, '21', where the meaning 'and' is more evident.

Number formation by means of a fractional value expressed in relation to the next higher unit is also found in WT: phyed-dang gnyis |1/2-and 2| means one and a half, which Jaschke explains as a subtraction: "which with an additional 1/2 would be = 2".

Analyzing this construction in Dzongkha as a subtraction (*back-counting* in Menninger's terms) is the first idea which comes to mind. It is quite plausible for the half-count. But for 3/4 the meaning of /ko/ in other contexts does not allow that interpretation. /phop pɹhe/ means '1/2 cup', and /phop ko/ '3/4 of a cup'. Thus /khe ko-da sum/ '55' cannot be read as "which with 1/4 would equal (3 x 20)", but only as "3/4 of 20 on the way to (3 x 20)", or to stick closer to intonation "3/4-on-the-way-to-3 (times) 20". Hence whatever the original meaning[12] of /ko/, the modern construction has to be understood as an instance of over-counting rather than back-counting.

Over-counting is apparently a very rare process in modern languages. A few scattered languages, especially in South and Central America and in the Germanic North of Europe show traces of it. In those Germanic languages where it appears, over-counting seems to be employed with fractional expressions, as in Dzongkha, while other numbers are formed by under-counting (adding units to the next lower multiple of the base).

In Maya, all numbers above 40 are formed by over-counting:

hun-kal	1.20	'20'	hun-tu-kal	1-on-20	'21'
ca-kal	2.20	'40'	hun-tu-y-oxkal	1-on-towards-60	'41'
ox-kal	3.20	'60'			

So '21' is 'one added to 20', but '41' is 'one in the interval whose upper limit is 60'. In Chol, a modern Mayan language, Aulie quotes over-counting as occurring with all numbers above 20:

wək-luhun-koht	i	čaʔk'al
6 - 10 - animal	to	40
36 animals.		

(On the use of the unit-counter 'animal' inside the number see the Dzongkha parallel below.) In many languages, over-counting exists only as traces. A case in point is Latin *sestertius* 'sesterce', from *semis-tertius 'half of the third' meaning 2 and 1/2 (with *as*, the monetary unit, understood).

Menninger explains the use of back-counting and over-counting by the need to visualize large numbers better. This idea may help us understand why Dzongkha makes use of 1/2 and 3/4, but not 1/4, in building larger numbers as well as in the ordinary use of the fractions. 1/4 has little conceptual interest: it is just as easy to use the corresponding number of units of the lower rank (in the number system and in the measure systems equally). This may explain also why fractions smaller than one are not used in number building.

c. Intermediate numbers 2: adding to the next lower multiple of the base

Other number names are built through an arithmetical expression starting with the name of the largest base contained in the number, followed by a multiplier ('1' included and necessarily overtly expressed) followed by the name of the base of the next lower rank if present and its multiplier, and so on down to the units (from 1 to 19). The successive ranks of the base may or may not be connected by /da/ ~ /dã/. The conditioning of the use of the connector is not clear yet.

Thus from 20 to 400, the structure will be:

khe ci:	20.1	20
khe ci: (da) ci:	20.1 (and) 1	21
khe ci: (da) 'ɲi:	20.1 (and) 2	22
...		

In Dzongkha, numbers with a fractional component cannot be used to build higher numbers:

khe pɣhe-da 'ɲi:	20 1/2-& 2	30
but khe ci: da cuci	20 & 11	31

In Dungkarpa (Eastern Bhutan) such constructions are possible: e.g. '31'

khe phedaŋ zon niŋ the

20 1/2-& 2 and 1

Numbers over 400 follow the same principle:

ɲiɕu ci:	20^2.1	400
ɲiɕu ci: da khe 'ŋa	20^2.1 and 20.5	500

And so do larger numbers:

jã:-chø ci: dã ɲiɕu 'ŋa tsa 'ŋa

20^4 1 & 20^2 5 20 5

160 000.1 + 400.5 + 20.5 = 162 100

with fractions liable to appear in the last component of the number:

khe-che ci: da ɲiɕu pɟhe-da sum

20^3 1 & 20^2 1/2-& 3

8000.1 + 400 (2+1/2) = 9 000

The use of /tsa/ for 20 in the vigesimal system:

The old Proto-Tibetan connective *tsa, reinterpreted as a bound form of 'twenty' in the decimal system, has also been borrowed in the vigesimal system as a perfect synonym of /khe/, semantically and syntactically. In the vigesimal system /tsa/ is multiplied by the following unit, like /khe/ while in the decimal system the unit following /tsa/ is added to it. Ambiguity is avoided by restricting the use of /tsa/ in the vigesimal system to contexts where it is preceded by larger bases:

ɲiɕu ci: daŋ tsa ci:	20^2-1-&-20-1	420	(vigesimal)
tsa-ci	20-1	21	(decimal)

d. Unit-counters : the overt expression of the base of rank zero

In large numbers, when objects are counted (as opposed to an abstract enumeration of number names), if the number is not an exact multiple of a base and units (from 1 to 19) are left to express, the unit number is usually preceded by a morpheme which is in most cases identical to the name of the object counted:

ra khe cuthãm dã ra ci:

goat 20 10 & goat 1

201 goats.

or, for a couple of words, different but apparently synonymous:

no: khe cu dã no:do ci:

cow 20 10 & cow 1

201 cows

tiru khe cutham dã lep ci:

Rs 20 10 & Rs 1

201 rupees

If money is being counted one rupee at a time, the initial /tiru/ is likely to drop, but the internal /lep/ tends to be kept:

ɲiɋu ci: dã tsa ɖhu lep ɖyn

20^2 1 & 20 6 Rs 7

527 rupees

Unit-counters and classifiers

It could be tempting to consider these morphemes as classifiers. But the rather vague notion of 'classifer' does not seem to shed any light on the Dzongkha construction. There are a number of differences between the Dzongkha unit-counters and the standard classifier construction (at least as interpreted by linguists), the most important of which is conceptual, with surface manifestations of course.

Greenberg (1974) correctly assesses the basic feature of classifiers to be unit-counters, but in 'classifier languages' they are not only that. I believe that Greenberg's statement (1974:24) sums up the general concept of a classifier: "It is our working hypothesis that unit-counters are modelled after the construction of mass nouns which cannot stand directly with numerals but require a measure or quasi-unit counter as an intermediary." (emphasis mine)

This second aspect of the function of a classifier has three syntactic consequences which are contradicted in the Dzongkha use of unit-counters. 1) Classifiers are used alongside the name of the object counted, 2) they are typically used with small numbers (numbers smaller than the fundamental base of the system), and 3) they can be used with round numbers which are exact multiples of bases of the system. The Dzongkha unit-counter does not have these characteristics. It can be used with numbers smaller than

20 instead of the usual name of the object (never along with it), but this remains optional:

ŋa-lu { no: / no:do } cutham jø

me-to cows 10 have

I have ten cows

It is never used with round numbers where the groupings in terms of multiples of 20 have exhausted the supply of objects to be counted. This is different from a language like Chinese which says /yì qiān běn shū/ 'One thousand Classifier books = 1000 books', although there are no units left to express after the thousands.

Units and groupings

I borrow here a sub-title used by Menninger which reflects well the function of the construction in Dzongkha. Rather than being pulled out of the number system under the name 'classifier' and thus compared to measure words, the unit-counters in Dzongkha should be integrated in the number system as the concrete expression of the abstract notion "unit", i.e. the fundamental base to the nul power (for Dzongkha $20^0 = 1$). This type of construction can be found in a number of other languages. Menninger (72) cites:

Old Norse: fiora dagar ens fiorþa hundraþs

4 days in 4th hundred

4 days in the 4th (strong) hundred [=120] hence '364 days'

Celtic: un march ar dec

1 horse and ten

11 horses

The repetition of the name of the object counted with the units in Dzongkha should be considered as an overt expression of the nul power of the base, and integrated into the series of base names. Thus a Dzongkha number is a formula of the type:

$$20^4 \times e + 20^3 \times d + 20^2 \times c + 20^1 \times b + 20^0 \times a$$

In the same way that 20^3 is not expressed if $d = 0$, 20^0 is not expressed, i.e. the unit-counter (or the repetition of the name of the object counted) is not used, if $a = 0$.

If the idea of a classifier is to make notions which are essentially collective countable by individualizing their members, the Dzongkha construction is the contrary of a classifier construction: everything is eminently countable, and the groupings which constitute the bases of the number system are themselves countable like any other object. In this respect the Dzongkha number system may manifest more clearly than others the hierarchically ordered system of groupings which forms the backbone of all number systems, but which has become less perceptible with the development of abstract computation.

V. COUNTING BY PAIRS

A small number of objects, mainly shoes, bullocks and tiles, are always grouped by pairs for counting. If the basis in nature for shoes and bullocks, which are always used by twos for ploughing, is rather obvious, it remains mysterious for tiles, since according to our informants tiles are of the flat slate type, and not of the terracotta type, where a top one and a bottom one could be paired. There must be some historical reason which will appear when someone is able to do field work in Bhutan.

Bullocks, /'lã:/, are counted in /dho:/ (WT dor), tiles, /ɕĩ:le/ or /ɕimto/, are counted in /zhũ:/, and shoes, /lham/, are counted in /cha/ (WT cha).

ŋa-lu 'lã: dho: ci: jø
me-to bullock pair 1 have
'I have a pair of bullocks.'

ɕĩ:le zhũ: khe ci:
tile pair 20 1
'20 pairs of tiles, 40 tiles'

lham cha ci:
shoe pair 1
'a pair of shoes'

If a single member of a pair has to be referred to, bullocks and shoes allow the use of the simple numeral 'one' /'lã: ci:/, /lham ci:/, although the form /cha mi ci:/ (or eventually /cha mep-ci/) is preferred

'lã: cha mi ci: |bullock pair ??not one| 'a single bullock'

For shoes /ja/ (WT ya) is also found (and can also be used for 'a single arm, leg,...'): /lham ja ci:/ 'a single shoe'.

The Dzongkha pair is not the base of a binary number system, since no higher number is formed on the base 2. Nevertheless, it is, like the several bases of the vigesimal system, a grouping of countable objects, and not a measure word. Syntactically, the pairs behave like the bases of the vigesimal system, and differently from measure words:

1) they use the half count only in numbers larger than the base:

zhũ:	khe	ci:	da	zhũ:	pɟhe
pair-of-tiles	20	1	and	pair	half

'Twenty pairs (of tiles) and a half = 41 tiles'

(but note that over-counting is not allowed). For measures, /pɟhe/ can be used for amounts less than the measure; typically any measure + /pɟhe/ is half that measure. As we have seen, 'only one of a pair' cannot be expressed as 'a half pair'.

2) pairs are counted with the ordinary numbers 'one' and 'two', while measures replace these by the words 'full' (Dz /ghã:/, WT gang-ba) and 'double' (Dz /dho/, WT do):

pɟeʈhe {ghã: / *ci:} 'one span' *but* zhũ: { ci: / *ghã: } 'one pair'

pɹeṭhẹ { dho / *'ɲi } 'two spans' zhṹ: { 'ɲi / *dho } 'two pairs'

CONCLUSION

Dzongkha exhibits a coherent vigesimal system equal in complexity and extension to any vigesimal system described in any part of the world. It is our best evidence as to what some of the old Tibeto-Burman number systems must have been like. There is no reason to believe that all Tibeto-Burman languages had developed a vigesimal system in the past, although a large number of them certainly had. But other types of systems, like the Chepang duodecimal system, may also have been more extensive than they are now. Evidence of some binary counting more extensive than the Dzongkha pairs can be found in the Dzongkha hierarchy of length measures, and in the measure systems of other Tibeto-Burman languages in Nepal, although Indo-Aryan influence is possible here. The preservation of the Dzongkha vigesimal system is largely due to the socio-political independence of the country and the status of Dzongkha as a national language. Number systems on different bases may have been as ancient in Tibeto-Burman, but did not find the proper cultural conditions to develop and, most importantly, to resist the spread of the all powerful decimal system which had the support of both India and China.

NOTES

1. Data used in this paper was collected from Bhutanese speakers in New Delhi by Boyd Michailovsky and myself, in Jan-Feb 1977. Number names quoted here can also be found in a booklet *An Introduction to Dzongkha*, New-Delhi, 1977, 101p., (anonymous). An earlier version of this paper was read at the XVth International Conference on Sino-Tibetan Languages and Linguistics, Beijing, China, 1982. Comments from B. Michailovsky and A.M. Blondeau are gratefully acknowledged. Abbreviations: Dz, Dzongkha; CT, Central Tibetan; WT, Written Tibetan.

2. Dzongkha phonemic system:

CONSONANTS

Class	I	II	III	IV	Sonant		
Tone	High		Low		H/L		High
velar	k	kh	g	gh	ŋ		
palat	c	ch	ɟ	ɟh	ɲ	j	
retrofl	ʈ	ʈh	ɖ	ɖh		r	
dent	t	th	d	dh	n	l	lh
lab	p	ph	b	bh	m	w	
dent aff	ts	tsh	dz	dzh			
lab aff	pɟ	pɟh	bɟ	bɟh			
pal fric	ɕ		ʑ	ʑh			
dent fric	s		z	zh			

VOWELS

i	y	u
e	ø	
e		o
	a	

DIPHTONGS

	ai	
iu		
eu		ou
	au	
	a:u	

Plain vowels can be long (written v:) or short, and nasalized (ṽ) or not. The phonemic status of /e/ is not clear yet.

Depending on the dialect, consonants of class IV are pronounced either plain voiced with low tone (merging with class III consonants), or voiceless aspirated (like class II consonants) but with the low tone. /ʐh/ and /zh/ stand respectively for a dialectal variation between low-toned /ʂ/ and /ʐ/ and between low-toned /s/ and /z/. This transcription has the advantage of accounting for the dialectal variation, and reduces the need to mark tones to those initials where a contrast exists: words with a vocalic or sonant initial. For these, low tone is left unmarked, and high tone is marked by an apostrophe before the word, e.g. /'ŋa/ '5'.

More work has to be done on the tone system. Only the high/low contrast is marked here, but there is a melodic contrast on long open syllables.

3. The prefix in WT g-nyis '2', and the resulting high tone in CT and in Dzongkha, may be a secondary development. Other Bodish languages, like the Tamang group, have a low-tone, implying a voiced nasal at the Proto-Tamang level (*ni:).

4. In these forms, -p- etymologically belongs with the second syllable (cf. WT bzhi-bcu, lnga-bcu, dgu-bcu), but phonemically

it belongs to the first syllable in Dz (this is not the initial affricate /pʒ/). For '80' WT has brgyad-cu; -p- in Dz may be etymological as well as analogical.

5. Except for /re/, the reduced forms of the names of the units used for the tens correspond etymologically, in Dzongkha as in Tibetan, to prefix-less forms of the names of the units. The phonemic reflexes in Dzongkha are:

	voiced obstruant (4,7,9)	nasal (2,5)
with prefix	voiced + low tone	high tone
without prefix	voiced + low tone voiceless aspirated + low tone	low tone

/ʒa/ for '80' is irregular.

6. The final -k in the bound forms of 1 and 6 is etymological. The -p inserted after 4, 5, 8, and 9 may be the original prefix of bcu '10', and brgya '100', preserved intervocalically in the series of the tens and hundreds, and introduced by analogy in the thousands (cf WT stong '1000').

7. In Maya, Menninger (61) believes that the vigesimal system was a learned invention of the priestly caste, artificially developed for astronomical computation, while an older decimal system remained in use for everyday life. The Dzongkha situation is exactly the reverse. It seems clear to me that

the vigesimal system is indigenous, and that the decimal system was borrowed from Tibetan for elegant speech.

8. The same root for '20' is found in many closely related languages: Gongar dialect (Bhutan, according to Hofrenning) spelled khay, probably /khe/; Dungkarpa /khɛ/; Sikkimese /khe/; Tamang /^{4}pokal/, Jirel, Sherpa and Thakali /khal/; Lepcha /kha/; Tipra (Bodo-Garo) /khol/ etc.;cf.Benedict, Conspectus n°397 TB *(m-)kul.

9. On Dzongkha measure names see Mazaudon, "Dzongkha Numerals", XVth International Conference on Sino-Tibetan Languages and Linguistics, Beijing, China, 1982, pp.22-26.

10. On Tamang phonology and transcription see Mazaudon, Phonologie du Tamang, Paris, SELAF (5 rue de Marseille, 75010 Paris), 1973. /^{4}/ is a low falling-rising-falling tone.

11. Chepang: /yaat.haale/ |1.12| '12', /yaat.haale yaat.jo?/ |1.12 1| '13', /yaat.haale ?aat.gotaa/ |1.12 8| '20', /nis.haale pongaa. jo?/ |2.12 5| '29', /sum.haale play.jo?/ |3.12 4| '40', /pongaa. haale/ |5.12| '60'. (Note the unit-counter /jo?/ on native numbers, corresponding to /gotaa/ on Nepali loans.) The duodecimal system apparently stops at 60. Duodecimal forms in Chepang are now rarely employed and tend to be replaced by Nepali loans. TB roots are kept up to 5, and for the base '12'. (Source: Ross C. Caughley, *A Vocabulary of the Chepang Language*, Summer Institute of

Linguistics, Kirtipur, Nepal, 1972, mimeo 40p.) NB: In the collective volume *Clause, Sentence and Discourse Patterns in Selected Languages of Nepal*, A. Hale, ed, SIL, Norman, Oklahoma, 1973, vol. 4, p.202-204, the Chepang number names are displaced one column to the left starting with '39'.

12. The etymology of the construction may be a subtraction, if /ko/ ever meant 'a little'. The only allofam I could find in this direction is WT khol-bu 'a small piece'. In numeral systems across languages it is frequent for the names of bases or their multiples to be deleted (understood). Hence a construction like /phop ko/ '3/4 of a cup' may have stood for *phop ko-da ci: |cup *ko*-and 1| 'what, with a little, would make 1 cup', in the same way /phop pɟhe/ '1/2 a cup' could have stood for *phop pɟhe-da ci:. A later reinterpretation of the regularly truncated construction could have led to a meaning shift in /ko/ from 'a little', or 'one quarter' to the modern 'three-quarters'.

This would not be a recent evolution though, since in his 1909 grammar (p.22) St Quintin Byrne gives p'ye gi p'ye (1/2 of 1/2) as a translation for '1/4', which confirms the absence of a specific term for 1/4. He also quotes the word ko as meaning '12 annas' (one anna is 1/16 th of a rupee).

REFERENCES

Aulie, Wilbur, "High-layered numerals in Chol (Mayan)", IJAL 23:4, 281-3, 1957.

Benedict, Paul K., Sino-Tibetan, a Conspectus, Cambridge University Press, 1972.

Byrne, St Quintin, A Colloquial Grammar of the Bhutanese Language, The Pioneer Press, Allahabad, 1909, 72p.

Chakravarti, S.K., "Reflection on Tipra Numerals", Pines 1:1 (Shillong, India), 74-76, March 1971.

Dixon, Roland B. and A.L. Kroeber, "Numeral systems of the languages of California", American Anthropologist 9:4, 663-690, 1907.

Greenberg, Joseph,

1974 "Numeral classifiers and substantival number: problems in the genesis of a linguistic type", Proceedings of the 11th International Congress of Linguists (1972), ed. by Luigi Heilmann, Società editrice il Mulino, Bologna, 1974, vol. 1, 17-37.

1978 "Generalizations about numeral systems", in Universals of human language, 3: Word Structure, ed. by J.H. Greenberg, C. Ferguson, and E.Moravcsik, Stanford University Press, 249-295.

Hofrenning, Rev. Ralph W., First Bhutanese Grammar, 13 pages, mimeographed, Dec 1959, (UC Berkeley catalog n° PL 3651 G61H6).

Jaschke, H. A., A Tibetan-English Dictionary, first publ. 1881, 1968 reprint, London, Routledge and Kegan Paul Ltd.

Menninger, Karl, Number Words and Number Symbols, a Cultural History of Numbers, MIT Press, Cambridge, Massachussetts (1969), translated from the revised German ed. (1958), xiii-480p.

Sandberg, Graham, Manual of the Sikkim-Bhutia Language or Dé-jong Ké, Calcutta, 1888.