Chapter 7
4- and 6-Cycle Systems

Kay Owens and Glen Lean

Abstract Although there is evidence of 4 and 6 cycle systems in America, the 6-cycle systems in Papua New Guinea and Oceania only occur in areas of the southern side of New Guinea, namely a large island of West Papua (Indonesia) and crossing the border region into Western Province of Papua New Guinea. However, these systems have powers of 6. The 4-cycle systems are found with Non-Austronesian languages of some highlands provinces, often associated with 8-cycle and among pockets of languages on the northern coast of Papua New Guinea together with some Austronesian languages of West Papua's northern coast. The chapter concludes with a brief commentary of the survey covered in Chapters 3 to 7.

Keywords 4-cycle systems • 6-cycle systems • counting practices

The Existence and Nature of 4-Cycle Systems

Among the world's languages the occurrence of 4-cycle numeral systems is comparatively rare. Schmidt (1929) said "the quaternary system forms the numerals above four by composition: 5 = 4 + 1, 7 = 4 + 3, 8 = 4 + 4 (or 2 × 4), 9 = (2 × 4) + 1, 16 = 4 × 4. In this consequent type, however, it is but seldom met, for example in California with the Salina and traces of it with the Chumash" (p. 614). Eells (1913), in discussing the Amerindian numeral systems indicates that "fairly well defined quaternary systems reaching to eight may be found among the Montaignais of the far north, the Foxes of Wisconsin, the Iowas and Missouris of the Plains - but they find their best and fullest development into true systems in various California tribes"(pp. 295-296). Dixon and Kroeber (1907), in their article on Californian numeral systems, confirm this: "Counting by fours is a striking feature of Californian languages" (p. 667). Beeler (1964) also documented the existence of 4-cycle systems among the Ventureño of California. Generally speaking, the 4-cycle system has not been documented in any other region except Africa where only one or two instances of numerals being compounded such that 8 = 2 × 4, 9 = (2 × 4) + 1, and 16 = (2 × 4) × 2 have been recorded. Zaslavsky (1973) cited "the Haku language of Central Africa" (p. 46) as having a numeral system with these features although the system is not purely 4-cycle having, for instance, 7 = 6 + 1 and a distinct word for 10. Beeler (1964) remarked that there is a vestigial trace of a 4-cycle in Proto Indo-European in that the numeral 8 is the dual form of 4; in the Indo-European languages as a whole, however, there is no sign now of 4-cycle features (p. 1).

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Eells (1913), in discussing how 4-cycle systems might arise, said that "perhaps a few tribes, for reasons best known to themselves, did not use their thumbs in counting" (p. 296). He also speculated that the number four held special ritual significance for many Indian tribes, as does Schmidt (1929) "in California the four quarters of the sky play an important part in religion, mythology and custom" (p. 614). Dixon and Kroeber (1907), however, dismissed this latter view: "it is probably not connected to any extent with ritualism … the Californian Indians are distinctly unritualistic" (pp. 667-668). They also indicated that the Californian 4-cycle systems often have terms which refer to fingers, implying that they are a type of digit tally and they added that "it does not follow that because people count by their fingers they count by fives" (Dixon & Kroeber, 1907, p. 668). This view is supported by the data reported below.

In Papua New Guinea, there were only 14 languages of those collected with 4-cycle systems. The 10 NAN languages are: Vanimo, Rawo, the Melpa and Kaugel dialects of Hagen, various dialects of Kewa, Wiru, Nafri, the Island dialect of Boiken, Enga, the Angal Heneng dialect of Mendi, and Mountain Arapesh. The four AN languages are: Bam, Wogeo, Ormu, and Yotafa. Some of these are discussed below. See Figure 7.1 for their distribution.

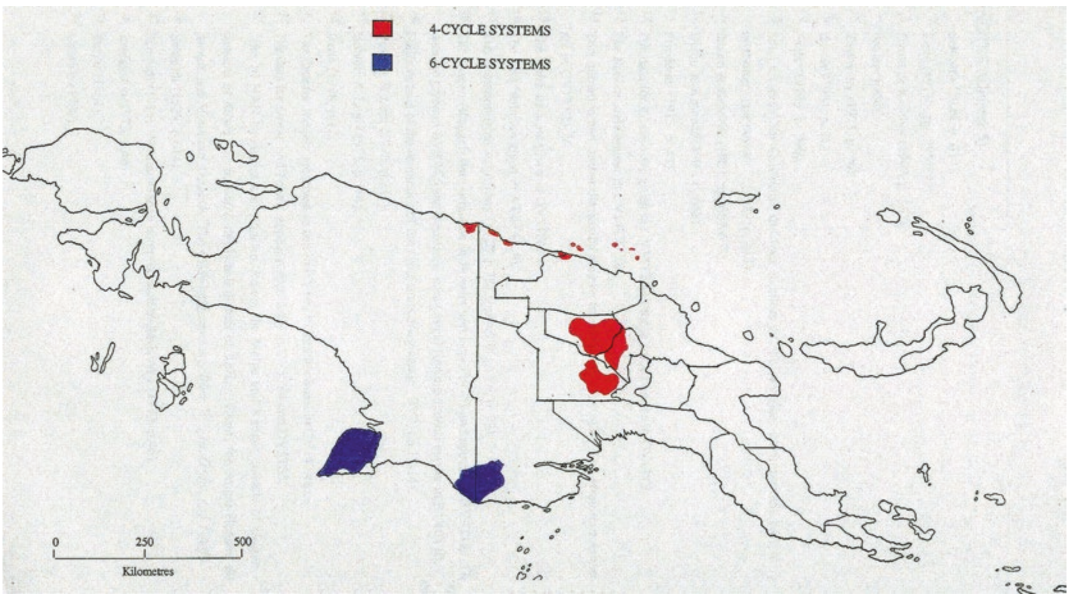

Figure 7.1. Distribution of 4-cycle and 6-cycle counting systems in New Guinea.

4-Cycle Systems Among the NAN Languages

Among the NAN languages of the New Guinea region, 4-cycle systems are rare: only about 10 or 11 languages possess numeral systems which exhibit, in whole or in part, features which are clearly 4-cycle in nature. These languages are located mainly in two geographical areas: the northern coast of New Guinea and the central highlands of PNG (see Figure 7.1). Two languages, Vanimo and Rawo, both of which belong to the Sko Phylum, and which are spoken in the West Sepik Province (PNG), had their numeral systems recorded by Friederici (1913, p. 42). According to this report, both systems were 4-cycle. The data are given below in Table 7.1. In both of these systems we have three monomorphemic numerals 1 to 3 while 4 is a "hand" morpheme *no-* or *nu-* (which normally has possessive suffixes). The numbers are tallied on the fingers of one hand excluding the thumb.

The Vanimo data indicate an alternative for 10, *moti*, a distinct term, and data recently collected by the author indicate that the Vanimo system no longer uses the (4 × 2) + 2 construction for 10 and has instead a secondary 10-cycle.

Table 7.1
Numerals of Vanimo, Rawo, and Boiken Island Dialect

Numeral	Vanimo	Rawo	Boiken
1	*opa*	*opa*	*nese*
2	*yumono*	*yemeno, yumunu*	*siti, yiti*
3	*enu*	*eno, ino, inomumu*	*sumungkulung*
4	*no*	*no, nu-o*	*nawata*
5	*no meneau*	*no meu*	*(nawata) hifuase*
6	*no meneyu*	*no me yu* 4 + 1	*(nawata) hifuayiti*
7	*no menehendu*	*no me 'no* 4 + 2	*(nawata) hifuamungkukung*
8	*nuyu*	*no yo* 4 × 2	
9	*nuyu meneau*	*no yo meu* 4 × 2 + 1	
10	*nuyu meneyu, moti*	*no you meyu* (4 × 2) + 2	

Note. 1. Vanimo and Rawo data were taken from Friederici (Friederici, 1913). Boiken dialect from Tarawai Island and Walis Island were sourced from 6 Counting System Questionnaires (Lean's Appendix on Sandaun). 2, *u* in Rawo is a suppletive form of 1.

Further to the east, in the Sandaun Province (PNG), the Island dialect of Boiken, spoken in the Tarawai and Walis Islands, also has a 4-cycle system (Table 7.1). The remaining six dialects of Boiken, however, all of which are located on the mainland, have 5-cycle systems. Adjacent to the Boiken region and located on the mainland coastal region are the Mountain Arapesh who have an unusual numeral system first described by Fortune in 1942. This has two monomorphemic numerals 1 and 2; 3 is 2 + 1 and the system thus possesses a modified 2-cycle. There is a distinct term for 4, *nybat,* which, interestingly, means "dog". Fortune (1942) stated that

> counting from four to twenty-four proceeds on two roots for numerals … as follows: four one, four two, four three, *biogu nybat* (two fours or eight), eight one, eight two, eight three, *biogu atut* (three fours or twelve [the *nybat* being understood]), twelve one, twelve two, twelve three, *bigi biogu* (two eights or sixteen), and so on to *biogu atuga biogu* or twenty and from there similarly to *anauwip* or twenty-four. (p. 59)

To the west of the Vanimo-Rawo region, in West Papua, Nafri is spoken (Galis, 1960, p. 144). This is a member of the Sentani Family and its numeral system shows both 4- and 5-cycle features. It has four monomorphemic numerals 1 to 4 while 5 contains a "hand" morpheme *me*; 6 has a 5 + 1 construction. The compounds for 8, 9, and 10 each show a 4-cycle construction and are, respectively, 4x2, (4x2) + 1, and (4x2) + 2. None of the other members of the Sentani Family exhibit traces of a 4-cycle in their numeral systems. There are, however, two other languages adjacent to Nafri which possess numeral systems showing 4-cycle features; these are Ormu and Yotafa, both of which are Oceanic AN and which are discussed in the next section.

The only other coastal or island NAN language which shows some trace of a 4-cycle in its numeral system is Yele, spoken on Rossel Island in the Milne Bay Province (PNG). While the numerals 1 to 10, and the decades and hundreds, show no trace of a 4-cycle, we find, however, that the thousands, used for counting shell money, do (Armstrong, 1928). These are given below in Table 7.2.

In the sequence given in Table 7.2 there is an *x* + *n* construction for the numerals 5 000 to 8 000 where *x* is *mwa-* and *n* takes, respectively, the values 1 000 to 4 000. Normally, for a 4-cycle system, 8 000 would have a multiplicative construction (4 000x2) rather than an additive one. The 4-cycle construction does not continue after 8 000, and 10 000 has the surprising construction (9 000) (8 000). Armstrong, who studied the Rossel Islanders in the 1920s, said that this is explained in a legend about a mythological being, Wonajo, who invented counting and "having counted up to 9 000 grew weary, and, unable to think of a fresh word for 10 000 adopted the novel, if unmathematical, device of using in juxtaposition the words for the last two thousands" (Armstrong, 1928, p. 78).

Table 7.2
The Yele Numerals 1 000 to 10 000

Numeral	*Yele*
1000	*yili*
2000	*dwong*
3000	*teme*
4000	*dab*
5000	*mwa yili*
6000	*mwa dwong*
7000	*mwa teme*
8000	*mwa dab*
9000	*mwa di*
10000	*mwa di mwa dab*

The remaining 4-cycle systems are all located in the PNG highlands and several of these are remarkable and unique. Two standard 4-cycle systems, however, are exhibited by Wiru and the various dialects of Kewa, both languages spoken in the Southern Highlands Province (PNG). The numerals are given in Table 7.3.

Table 7.3
4-Cycle Systems of Wiru and Kewa

Numeral	Wiru	Kewa
1	*ondene*	*pameda*
2	*takura*	*laapo*
3	*tebolo*	*repo*
4	*tuyono, lu-u*	*ki*
5	*lu ke ondene*	*kode, kina kode*
6	*lu ke takura*	*kode laapo*
7	*lu ke tebolo*	*kode repo*
8	*lu-u takura*	*ki laapo*

Both systems have the numeral 4 containing a "hand" morpheme, *yono* in Wiru and *ki* in Kewa. The use of the "hand" morpheme, for both systems, indicates that the fingers but not the thumb are tallied. The nature of the Kewa system becomes apparent when we consider the semantics of the numbers 5 to 12, the data deriving from an article by the SIL linguists Karl and Joice Franklin and given in Table 7.4. The Wiru and Kewa 4-cycle systems are not the only means of enumeration for these language groups: both possess body-part tally systems, that for Kewa having a 47-cycle.

Table 7.4
The Semantics of the 4-Cycle System of (East) Kewa

Numeral	Kewa	Body-Part Translation
5	*kode*	the thumb
6	*kode laapo*	two thumbs, i.e. one hand and two thumbs
7	*kode repo*	three thumbs, i.e. one hand and three thumbs
8	*ki laapo*	two hands
9	*ki laapo na kode*	two hands, one thumb
10	*ki laapo kode laapo*	two hands, two thumbs
11	*ki laapo na kode repo*	two hands, three thumbs
12	*ki repo*	three hands

Three unusual 4-cycle systems which employ a similar principle of enumeration are exhibited in the languages Enga (Mai dialect), Hagen (Kaugel dialect), and Mendi (Angal Heneng dialect) which are spoken, respectively, in the Enga, Western Highlands, and Southern Highlands Provinces (PNG). Typically, these systems are such that counting proceeds initially from 1 to 8. Beginning at 9, there comes into play a means of proceeding by fours which employs what Lean termed "cycle units". In counting a particular sequence of four, for example 13 to 16, the cycle unit for that sequence is a word or phrase, perhaps a mnemonic, which is employed to form the compounds for 13 to 16 in the following way:

13 cycle unit + 1
14 cycle unit + 2
15 cycle unit + 3
16 cycle unit completed

In enumerating the next sequence of four, a different cycle unit is used but the same constructions are retained. To illustrate this, Table 7.5 shows enumeration of the sequences 13 to 16 and 17 to 20 for each of the three languages.

Table 7.5
Examples of Cycle Units in the 4-Cycle Systems of Enga, Angal Heneng, and Kaugel

Numeral	Enga	Angal Heneng	Kaugel
1	*mendai*	*pombor*	*telu*
2	*lapo*	*kap*	*talu*
3	*tepo*	*tep*	*yepoko*
4	*kitome(n)de*	*makl*	*kise*
8	*tukulapo*	*tukap*	*enggaki*
12	*tukutepon(ya) gato*	*tutep*	*rurepo*
13	*mapunya mendai*	*moklaopun pombor*	*malapungga telu*
14	*mapunya lapo*	*moklaopun kap*	*malapungga talu*
15	*mapunya tepo*	*moklaopun tep*	*malapungga yepoko*
16	*mapunya gato*	*tu moklaopu*	*malapu*
17	*yupunya mendai*	*supun pombor*	*supungga telu*
18	*yupunya lapo*	*supun kap*	*supungga talu*
19	*yupunya tepo*	*supun tep*	*supungga yepoko*
20	*yupunya gato*	*tu supu*	*supu*

Note. Kaugel data were from Bowers and Lepi (1975) and similar to 25 Counting System Questionnaires (CSQ); Angal Heneng data from 17 CSQs; Enga data from Lean's field visit to Mai dialect informants and given by Lang (1973).

For the Enga data shown, the cycle unit for the sequence 13 to 16 is *mapun(ya)* which means "sweet potato", while that for the sequence 17 to 20 is *yupun(ya)* which has the gloss "ground, earth". Bowers and Lepi (1975) indicated, for the Kaugel system, and the same is true for the other two, that

> unlike English or Pidgin numeration, when a set of four has been completed, the next three items are considered parts of the following named set rather than addition to the just-completed set, for example *supungga talu* "2 of 20" i.e., 18 (p. 313).

The enumeration in fours terminates at a different value for each system: Enga at 60, Kaugel at 32, and Angal Heneng at 48. In the case of Kaugel, 32 does not constitute a secondary cycle: the term for 24, *tokapu*, is used to form compounds for larger numbers so that 48 = 24 x 2, that is *tokapu talu*, and 72 = 24 x 3, that is *tokapu yepoko*.

This type of 4-cycle system is not documented in the literature of numeral systems for any other region in the world. Its uniqueness implies that the principle of the cycle unit as a means of enumeration is an independent and localised invention. It seems likely, however, that the 4-cycle nature of the systems has the same basis as other 4-cycle systems which exist in this region, that is treating the "hand" as four fingers. Bowers and Lepi (1975), indeed, suggested that, for the Kaugel system, "the everyday system was probably derived from finger counting" (p. 314). Both numerals 4 and 8, for Kaugel, contain a "hand" morpheme *ki*. Similarly, the number 4 in Enga, *kitomende*, also contains a "hand" morpheme *ki*, a feature shared by Wiru and Kewa, discussed earlier, as well as by the Melpa dialect of Hagen in which 8 contains a "hand" morpheme.

4-Cycle Systems Among the AN Languages

Only four AN languages possess numeral systems which exhibit 4-cycle features. Two of these, Wogeo and Bam, both of which belong to the Manam/Kairiru chain of the North New Guinea Cluster (Ross, 1988, p. 122), are spoken in the Schouten Islands in the East Sepik Province (PNG). The data for these systems are given in Table 7.6.

Table 7.6
Two 4-Cycle Systems of Oceanic AN Languages

	Wogeo	Bam
1	*ta*	*tini*
2	*ru*	*ru*
3	*tol*	*tuol*
4	*kwik*	*kiki*
5	*kwik bo koba*	*kikik be kubua*
6	*kwik ba rago*	*kiki be areg di ru*
7	*kwik be tol*	*kiki be areg di tuol*
8	*kiki ru*	*kiki ru*
9	*kiki tu bokoba*	*kiki ru be kubua*
10	*kiki ru barago*	*kiki ru be areg di ru*

Note. The Wogeo data were sourced from Friederici (1913, p. 42), Ray (1919, p. 328) and Kluge (1938, p. 177); Bam data from 2 CSQs and Laycock (1976, p. 416).

The Bam system is regular and shows clearly the pattern: 6 = 4 + 2, 7 = 4 + 3, and 8 = 4 × 2. While the numerals 1 to 3 are recognisable as reflexes of the Proto-Oceanic (POC) numerals but the numeral for 4 is not. It is not known whether, as is the case for the NAN 4-cycle systems, counting is done on the fingers but not the thumb of the hand. The word for "hand" in Bam is *lima*, identical to the POC numeral, which does not appear in the number 4; if it did this might lend some semantic weight to the idea that counting is done on the fingers only.

Two other Oceanic AN languages have numeral systems which possess 4-cycle properties. These are Ormu and Yotafa, both located on the north coast of West Papua adjacent to Nafri, a NAN language with a 4-cycle system discussed in the previous section. The data for these are given in Table 7.7.

Ormu displays a 4-cycle system with both 5 and 9 having "one", 6 having "two" and 8, as 2 presumably × 4. For Yotafa; 6 has "two", 9 is 8 + 1, *meniam* implies 4 and "one" which is similar to Vanimo's 4 + 1 (in Friederici's (1913) data 5 is *no menau* but other Vanimo data implies 4 and just

Table 7.7
4-Cycle Systems of Two Oceanic AN Languages in West Papua

	Ormu	Yotafa
1	*nitji*	*tei*
2	*rohi*	*ros, roti*
3	*toru*	*tor(u), ossor*
4	*awa*	*au(a)*
5	*ore-nitje-ma*	*meniam*
6	*man-rohi-ma*	*mandosim, ma-roti-ma*
7	*samecho-don-rohi-ma*	*tamecho-none-roti-ma*
8	*don-rohi-ma*	*none-roti*
9	*nen-rohi-fraja-nitje-ma*	*none-roti-fraja-tei*

Note. Ormu data were sourced from Galis (1960, p. 145) and Yotafa from Galis (1960, p. 144) and Batten (1894, p. 29).

gives 1 like Yotafa data). Interestingly, 7 contains the morphemes for 8 in both languages. This might suggest one more needed for the complete group of 8. As both of these languages do not possess systems with a 10-cycle which we might expect because both are daughter languages of POC, it is not known whether the 4-cycle properties apparent in their numeral systems is a result of influence by neighbouring 4-cycle NAN systems, that is those of Nafri and of Vanimo and Rawo to the east. Some sources for Vanimo have a distinct word for 10 suggesting a secondary 10-cycle. For Rawo, Friederici's (1913) data also give a 4-cycle but later CSQs give a distinct word for 5 and subsequently give 6 = 5 + 1. 7 = 5 + 2, 8 = 5 + 3, 9 = 5 + 4, 10 = 2 × 4.

Summary of 4-Cycle System Data

There is a total of 10 NAN languages (11 if we include Yele) and 4 AN languages which have numeral systems displaying 4-cycle features. Figure 7.1 indicates the distribution of these which is restricted to two main regions: 1) the northern New Guinea coast and islands, and 2) the central highlands of PNG. No 4-cycle numeral systems are found in Island Melanesia, Polynesia, or Micronesia, although counting objects in groups of four is quite common in these regions. Only several of the systems display "pure" 4-cycle features as described by Schmidt, that is 5 = 4 + 1, 7 = 4 + 3, 8 = 4 + 4 or 2 × 4, and 9 = (2 × 4) + 1. Ormu and Yotafa are AN languages have an unusual construction for 7, and the neighbouring NAN 4-cycle systems also have some data suggesting both 4 and 5 cycles. Mountain Arapesh and the Melpa dialect of Hagen both have a primary 2′-cycle as well as a secondary 4-cycle. Yele exhibits a 4-cycle structure for the thousands only while the Enga, Kaugel, and Angal Heneng systems have their unique 4-cycle sequences beginning at 9.

The evidence is clear that some 4-cycle systems arise due to the practice of treating the four fingers, but not the thumb, as one "hand". This is certainly the case for the NAN languages Vanimo and Rawo and those of the central highlands. There is, however, no lexical evidence suggesting that this is also true for the four AN systems. While it would appear that counting on the fingers in this way may well be a localised innovation for the central highlands languages, it is not at all clear whether there is a similar common thread connecting the nine 4-cycle systems of the northern coast and islands, that is whether these are largely small groups of 4-cycle counters which have developed their systems independently or, as seems more likely, whether the 4-cycle system was developed in one location and was then diffused, possibly by trading, along the northern seaboard.

The Existence and Nature of 6-Cycle Systems

6-cycle, or senary, systems are comparatively rare and the literature indicates their existence in only two major regions: Africa and North America, as indeed was found in the case of the 4-cycle systems. Schmidt (1929) noted that "it has a rather limited dispersion in north-west Africa, e.g., in the Huka, the Bulanda, the Apko" (p. 614). In her 1915 article on African numeration, Schmidl (1915) indicated several languages which use the principle of "composition with 6" and her map of the distribution of various systems shows some seven locations where this occurs. Zaslavsky (1973, p. 46), quoting Schmidl's material and map, gave several instances of systems with 6-cycle properties in which, for example, $12=6\times2$ and $24=6\times4$. The Balante (Schmidt's "Bulanda") have numerals 7 to 12 compounded as $7=6+1$, $8=6+2$, and so on.

In North America, 6-cycle systems appear to be limited to a few examples in the languages of California. Beeler (1961a) published an account of the Wintun, Nomlaki, Patwin and Maidu systems, each of these being members of California Penutian. None of these systems is pure 6-cycle in nature, that is in a pure system we would expect 7 to 11 expressed as $6+n$ where n takes the values 1 to 5 respectively, and $12=6\times2$. They do, however, exhibit some 6-cycle features in that $7=6+1$, $8=6+2$, and $9=6+3$. Gamble (1980), similarly, in his analysis of Chunut, also located in California, indicated vestigial traces of a 6-cycle numeral system.

6-Cycle Systems in the NAN Languages

Lean had no evidence of the existence of 6-cycle numeral systems among the AN languages of New Guinea and Oceania. There is, however, evidence that such systems exist in a small group of NAN languages which are located in two regions on the south coast of New Guinea (see Map 15). Three languages, Kimaghama, Riantana, and Ndom, are all spoken on Kolopom Island adjacent to the south coast of West Papua, immediately to the west of the West Papua/PNG border. The numeral systems of each of these languages possesses a primary 6-cycle; Kimaghama has a secondary 20-cycle while Ndom has a (6, 18, 36) cyclic pattern. The data for these systems are given in Table 7.8.

Table 7.8
Three Examples of 6-Cycle Numeral Systems of the NAN Languages

	Kimaghama	Ndom	Riantana
1	*növere, nubella*	*sas*	*mebö*
2	*kave*	*thef*	*enava*
3	*pendji*	*ithin*	*pendö*
4	*jando*	*thonith*	*wendö*
5	*mado*	*meregh*	*mata*
6	*turo, ibolo-nubella*	*mer*	*törwa*
7	*iburo-növere*	*mer abo sas*	*mebö-me*
8	*iburo-kave*	*mer abo thef*	*enava-me*
9	*iburo-pendji*	*mer abo ithin*	*pendö-me*
10	*iburo-jando*	*mer abo thonith*	*wendö-me*
11	*iburo-mado*	*mer abo meregh*	*mata-me*
12	-	*mer an thef*	*törwa-me*

Note. These data were sourced from Galis (1960, p. 148) and Drabbe (1926, pp. 6-7) with agreement from Boelaars (1950, p. 34) for Kimaghama.

Although these three languages are related, each belonging to the Kolopom Sub-Phylum-Level Family, the numerals of each system differ markedly from those of the others. Nevertheless, each exhibits a 6-cycle structure, that of Ndom being the most regular. In addition to the data shown, Ndom has distinct terms for 18 and 36; 72 and 108 are compounds of the latter, that is $72=36\times2$ and $108=36\times3$.

To the east of Kolopom Island, two other languages are located in the Western Province PNG, both of which possess 6-cycle systems. These are Kanum around the border of West Papua and PNG and Tonda further east. Both seem to belong to the same Sub-Family of the Trans-Fly Stock. Although the data for Tonda are incomplete, so that it is uncertain how the numerals 7 to 12 are constructed, nevertheless we do have $12=2\times6$ and $18=3\times6$. The data for Kanum are more complete: there are distinct terms for 1 to 6 and the numerals 7 to 12 have an $x+n$ construction where n takes, respectively, the values from 1 to 6. The alternative construction for 12 is 2×6, 18 is 3×6, and 24 is 4×6. There is a distinct term for 36, as we found with Ndom, and this forms a secondary cycle with $72=2\times36$. These various systems discussed here form the most fully displayed 6-cycle systems to be found anywhere in the literature. The data for Kanum and Tonda are given in Table 7.9.

Table 7.9
The 6-Cycle Systems of Kanum and Tonda

Numeral	Kanum	Tonda
1	*namper*	*nabi*
2	*jempoka*	*yalmbe*
3	*juau*	*yala*
4	*eser*	*hasar*
5	*tampui*	*tambui*
6	*tarawo*	*trawa*
7	*pesmeri-emper*	-
8	*pesmeri-jalmpö*	-
9	*pesmeri-jela*	-
10	*pesmeri-eser*	-
11	*pesmeri-tampui*	-
12	*pesmeri-tarawo*	*yalmbe trawa*
18	*juau-tarawo*	*yala trawa*
36	*nimpe*	-
72	*jempoka-nimpe*	-

Note. Kanum data were sourced from Galis (1960, p. 149) and Boelaars (1950, p. 38), Tonda from 1 CSQ.

Later data from Hammarström (2009) suggest there are several languages in the Kanum and Tondo groups with the latter seeming at this stage to include Tondo, Nambu, and Yei spread over a considerable area around the Morehead river. He noted that they all have words for 1 and 2, and then

> above 2, the vocabularies wholly diverge. Some vocabularies show a restricted system with $3=2+1$ and $4=2+2$, whereas others have a monomorphemic 3, $4=2+2$, and evidence of base-5 above that. In other words, proto-Nambu must have had a restricted system whereas some modern Nambu varieties show base-5, or incipient base-5 systems.

This is interesting as Lean (1992) considered a similar issue of a 4 and 5 cycle systems for some north coast of West Papua border languages (Ormu and Yofata). Both Lean and Hammarström note that Williams (1936) had recorded that the Keruka, a Nambu speaking group, used a 6-cycle system borrowed from the Tondo for counting a small variety of yam *taitu* but otherwise used a 5 cycle system. Their frame words were 1, 2, 36, 216, and 1 296 showing powers of 6 were used.

Williams (1936) noted that such systems should develop for yam counting (two groups of 3 yams) and Hammarström noted the use of the thumb parts suggesting a hand link as was found for the

5-, 10-, and 4-cycle systems although the semantic evidence is not so clear. There is, however, a special counting system employed by the Mountain Arapesh which offers a clue to the origin of 6-cycle systems. The Mountain Arapesh possess a 4-cycle system which was discussed in the previous section; they also possess another unusual system which has a (3, 6) cyclic pattern. The procedure used in this type of counting has been described by Fortune; after counting to 3, the count proceeds: "three one, three two, *anauwip* or six. Then repeat to a second *anauwip,* or twelve. This is supposed to be the count on the hands, five fingers and a thumb joint as well, to make six for each hand" (Fortune, 1942, p. 59). Thus, for this particular system, the 6-cycle does arise from finger tallying. We have found, therefore, that tallying on the hand gives rise not only to 5-cycle variants, but also to 4-cycle systems in which the thumb is excluded from the count, and to 6-cycle systems in which the thumb joint augments the four fingers and the thumb.

Donahue (2008) explained one of the more interesting developments in counting systems for Kanum. He noted there were in fact three systems, simple, moderate and complex (Table 7.10). In the

Table 7.10
Three Levels of Kanum Counting Systems

	Simple	Moderate	Complex
1	*naempr*	*aempy*	*aempy*
2	*yempoka*	*ynaoaempy*	*ynaoaempy*
3	*ywaw*	*ylla*	*ylla*
4	*eser*	*eser*	*eser*
5	*swabra*	*tampwy*	*tamp*
6	*'swy*	*traowao*	*ptae*
7		*psymery aempy* 6 + 1	*aempy ptae* 1 + 6
8		*psymery ynaoaempy* 6 + 2	*ynaoaempy ptae* 2 + 6
9		*psymery ylla* 6 + 3	*ylla ptae* 3 + 6
10		*psymery eser* 6 + 4	*eser ptae* 4 + 6
11		*psymery tampwy* 6 + 5	*tamp ptae* 5 + 6
12		*psymery traowao* 6 + 6 or *yempoka traowao* 2 × 6	*tarwmpao* 12
13			*aempy tarwmpao* 1 + 12
14			*ynaoaempy tarwmpao* 2 + 12
15			*ylla tarwmpao* 3 + 12
16			*eser tarwmpao* 4 + 12
17			*tamp tarwmpao* 5 + 12
18			*ntamnao* 18
19			*aempy ntamnao* 1 + 18
20			*ynaoaemy ntamnao* 2 + 18
24			*wramaekr* 24
25			*aempy wramaekr* 1 + 24
30			*ptae wramaekr* 6 + 24
31			*aempy ptae wramaekr* 1 + 6 + 24
36	$= 6^2$		*(ntaop) ptae* (big) 6
37			*aempy (ntaop) ptae* 1 + (big) 6
50			*ynaoaempy tarwmpao (ntaop) ptae* 2 + 12 + 36
100			*eser wramaekr ptae ynaoaempy* 4 + 24 + 36 × 2
216	$= 6^3$		*tarwmpao* 216
1296	$= 6^4$		*(ntaop) ntamnao* (big) 18
7776	$= 6^5$		*(ntaop) wramaekr* (big) 24

Source. Donahue (2008, p. 426)

complex system there is an economy of words in that the words for 12 and are reused in larger numbers. The multiplication is placed after the "units" in the higher numbers.

> Large numbers, such as '500' or '1976', can easily be formed: *ynaoaempy tarwmpay ynaoaempy ptae wramaekr ntaop ptae*, '(2 × 216) + (2 + 6 + 24 + 36)', and *ntamnao tarwmpay ylla ynaoaempy ptae wramaekr*, '1296 + (216 × 3) + 2 + (6 + 24)', respectively, though it should be noted that some younger speakers are reinterpreting *ntamnao* '1296' as '1000' when counting, almost certainly under the influence of dealings with Indonesian currency (for which the 1000 is the lowest banknote of value, resulting in a system in which almost all products are priced in multiples of 1000). This means that *ntamnao tamp* is effectively ambiguous between '5000' (1000 × 5; new reading) or '6480' (1296 × 5; old reading), although only the latter is prescriptively correct. (Donahue, 2008, p. 427)

Further data are available from Evans (2009) for another 6-cycle system Nen which belongs to the Morehead-Maro rather than Kanum branch of the Morehead-Wasur languages. It also had powers of 6 to 6^5 and possibly 6^6. He commented that the Kanum, Tondo and other Morehead-Wasur languages probably had a 6-cycle system with powers in Proto-Morehead-Wasur a long time ago. He quoted Williams (1936) who described the counting for another of the languages Keraakie. He described the custom of two men taking three yams each to a display with a counter noting the 6 and each group of 6 marking 36 with a yam and then the counters started to count the next $36 = 6^2$. This counting would continue as each power of 6 was reached. The practice seemed to indicate the necessity of having 6^4 stored. He provided an image of the 6 small yam radiating in a circle with the narrow ends touching in the centre (like a daisy). He also noted that the Yei who relied on sago rather than yams did not have a 6-cycle system. Thus a cultural context appears to have encouraged the counting with 6 being represented by the hand, the part of the hand for the number 6 varied with pointing to wrist protuberance (Nen) and encircling base of the hand (Kanum). $4 = 2 + 2$ and 5 is either the 5th finger or the back of the hand in the various languages. His informants also suggested abstract counting and that this counting was not just for counting yam although they also used two-hands for a 10 system in talking about the number of children. According to Evans (2009), further linguistic and anthropological data were needed to decide if the exponential system was diffused or belonged in the Proto Morehead-Wasur system.

Summary of 6-Cycle System Data and General Commentary

The situation regarding 6-cycle systems in New Guinea is similar to that pertaining in Africa and North America, that is that such systems are rare and are only found in a few locations. There are five NAN languages which possess systems with a primary 6-cycle; three of these are located on Kolopom Island in southern West Papua and two are located near the south end of the West Papua/PNG border. Apart from these two neighbouring regions, 6-cycle systems do not exist anywhere else in New Guinea or Oceania, and in particular are not found in any of the AN languages. As indicated above, one other NAN language, Mountain Arapesh, has a special counting system which has a primary 3-cycle and which terminates on a count of 6 (and thus does not actually have a secondary 6-cycle). The notable feature of the 6-cycle systems located in southern New Guinea is that they are the most fully formed 6-cycle systems found anywhere in the literature.

In concluding the survey given in the last five chapters of the various types of numeral systems and tally methods which exist in New Guinea and Oceania, it is clear that these possess a considerable, but not unlimited, diversity. Evidence has been presented to indicate the existence of numeral systems which have primary cycles of 2, 4, 5, 6, and 10. The special Mountain Arapesh system has a primary 3-cycle and there are two other systems, those of Bumbita Arapesh (Sandaun Province) (see Appendix B) and Wasembo (upper Markham River, Morobe Province), which appear to have features of a secondary 3-cycle. The secondary cycles of the numeral systems range through 3, 4, 5, 10, 18, 20, 36, 60, to 100. The system of the Melpa dialect of Hagen, which has a "hand" morpheme for 4, also has a distinct word for 8 and a consequent 8-cycle. Despite this diversity of cyclic structures, it is important to note that there is no evidence that any language in the region under consideration possesses a numeral system with either a primary or secondary cycle of 7 or 9 in the first decade although both numbers feature in Papuan languages where 10 completes a cycle (e.g. one of the Engan systems and Uisai in Bougeanville), or of 11, 12, 16, and 19 in the second decade. Many of the other numbers in the second decade occurred with an asymmetrical or truncated system.

Tallying on the fingers of the hand (and, by extension, the toes) gives rise to the common "digit-tally" system with a primary 5-cycle and a secondary 20-cycle. However, we have also found that digit-tallying can give rise to both 4- and 6-cycle systems depending, respectively, on whether the thumb is omitted from the tally or whether the thumb joint or wrist joint augments it. There is no evidence, however, that pure 2-cycle systems have their genesis in digit-tallying. Tallying on body parts other than digits as a primary way of developing a counting system appears to be rare around the world except in New Guinea and Australia. Of the 40 body-part tallies documented for New Guinea, the least complete cycle is 18, the greatest complete cycle is 68, and the modal cycle is 27. We therefore have a considerable range of unusual cyclic structures, each of which has its genesis in parcelling out the body for tallying. There are numerous systems that are truncated or asymmetrical in using the body-parts. There is evidence that such tallies are, or were, used for calendrical purposes, in particular for establishing when a certain feast should occur during a cycle of ceremonial feasts but other groups used these systems for many purposes. Language groups which possess body-part tallies almost invariably possess, in addition, a relatively simple numeral system, that is either a 2-cycle variant or, as we find in the Southern Highlands Province (PNG), a 4-cycle system. The body-part tallies functioned as ordinal devices, using the name of a body part to indicate the position of a point in an ordered sequence of points; the names of the body parts were not generally used (in noun phrases, say) for stating the number of objects in a set and for this the numeral system was used and which thus had an independent purpose and existence.

Another important point to note are the body-part tallies for multiples of powers of 10 (e.g., Yu Wooi, Mid-Waghi, Jiwaka Province) and 20 (e.g., Iqawaye, Eastern Highlands Province). Meanwhile, other representations and cultural contexts encouraged powers of numbers such as 6 (southern New Guinea) or 10 times powers of 2 (Oceania) or powers of 10 times powers of 12 (e.g. Tinatatuna or Tolai, East New Britain). This diversity indicates that large numbers were expressed and a sense of infinity was often associated with the systems of powers. This is in contrast to people who noted in recent field trips by Owens, the numbers "finished" at a particular number, usually 20 or systems with a 2-cycle system (NAN languages around Bogia, Madang Province), or with size (few, many) determined by the number of people or occurrences by which an action was taken (Western Province languages). Thus the cultural context often determined ways of thinking of number that were systematic but not limited to western arithmetic systems and perhaps not fully appreciated by western-thinking people. Nevertheless, recent data have shown a greater richness in the counting systems, adding to Lean's (1992) and Smith's (Smith, 1984, 1988) original extraordinary surveys and analyses.

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