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Native numeracy in tropical America

GORDON BROTHERSTON

In the history of the American continent, the beginnings of culture appear to have been concentrated in the broad tropical band which runs east-west from Brazil to Mexico. This is largely or entirely the case with regard to the development of such phenomena as agriculture, poisons, medicine, architecture, astronomy, mathematics, script systems and what has been recognized as cosmogony and the philosophy of origins. For its part, archaeology has long been able to supply proof of the considerable time depth and geographical cohesion of these developments. Yet such understanding of the cradle of the continent has most often met with strong ideological resistance: witness the professional misfortunes of scholars like Carl Ortwin Sauer (ostracized in the early 1950s for having suggested that maize was an American plant) and Donald Lathrap, whose 'ideation' of Amazonian roots continues to be treated sceptically.

At the same time, there is the testimony of native texts, in major narratives and other documents which reflect and indeed add new insights to the findings of archaeology. Thanks to fieldwork begun by Preuss, Koch-Grünberg and others a century ago, a whole corpus of texts represents Amazonia in this sense, prime examples being *Watunna* and *Jurupary*. From early colonial times, the urban societies of the Andes and Mesoamerica have provided their testimony, epitomized by the 'American Bible', the Maya *Popol vuh* (Edmonson, 1971). Above and prior to all, there is also the pristine antecedent that survives on the pages of the pre-Columbian books or 'codices' of Mesoamerica, and in newly deciphered hieroglyphic and other inscriptions that date from the Classic period and earlier. These native-script sources may be counted as an especially valuable and irrevocable part of the textual testimony.

On the particular question of numeracy, and of philosophies implicit in counting systems, it can be highly instructive to compare the two sets of evidence offered respectively by Mesoamerica, with its inscriptions and books, and lowland South America, whose shamanic traditions lie much closer to us in time. Accounts of numeracy in Mesoamerica are legion and generally share the assumption that, at the time of contact with Europe, local mathematics was far more sophisticated than that of the invaders; by contrast, numeracy in lowland South America has received scant attention (Aveni and Urton 1982; Closs, 1985; Urton, 1997). Yet careful comparison of key texts from each area may lend insight into not just the deeper history of the continent but the way that mathematical 'truth' is registered in tropical American texts.

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1. *Mesoamerica*

The diagnostic of this cultural area is generally accepted to be a highly complex calendrical system, which relies on two complementary cycles: the year of 18 (twice 9) twenty-day feasts; and the gestation period of 260 nights and 13 twenty-day 'weeks'. Statements made in this calendar are found in inscriptions which date back well into the first millennium BC, and in screenfold books and scrolls made of paper and skin, often called 'codices'. The script used in these sources may be considered iconic, with phonetically specific varieties (Zapotec, Olmec, lowland Maya); a feature common to all is the number and sign sets of the calendar. While the phonetic scripts tend to separate out 'writing' from 'arithmetic', and both from 'picture' (or for that matter symbolic logic or music), the iconic system does not. On the contrary, the pre-Cortesian books, notably those in the 'dreambook' genre, exult in the capacity to propose multiple levels of reading, which may be conceptual, or exist as literal registers on the page.

The sophistication of the calendrics and arithmetic found in the Maya hieroglyphic texts has been amply recognized and analysed, far more than is the case with their iconic counterparts, which, at the same time, diverge more radically from Western norms. Besides the nature of their recording medium, the iconic codices are notable for their intricate characterization of numbers and styles of counting. In his capacity as rainmaker, Tlaloc figures as number 8 in the set of 13 Heroes; as one of the nine Night Lords (yoallitecutin) who guard the nights and moons of pregnancy, he stands last as number 9, and his water is amniotic. Identified in both roles by his mask or literal persona, Tlaloc is not just a different absolute number in each case but occupies a proportionately different position within the set: 8/13 and 9/9. According to a similar logic, Eagle is both number 5 of the 13 Fliers (Quecholli) and 15 in the set of 20 signs: here, the correspondence between the two bird of prey matches that which connects serial with cumulative or 'sigma' counting (i.e. $\Sigma 5=1+2+3+4+5=15$). The notion of fivefold or digital seizure may also be expressed as that total to the power (i.e. $5 \times 5 \times 5 \times 5 \times 5$), while three lots of Nine are commonly represented as 3 cubed or to its own power (i.e. $3 \times 3 \times 3$). In the *Historia tolteca chichimeca* (ff. 16-21), the 'mirror' deity Tezcatlipoca defines himself as 'the one who is two, the one who is three' (machome, machney) when urging the Chichimecs to emerge from Seven Caves; and effectively the total of those who emerge, 108, proves to be the product of those numbers to their own power, or $2^2 \times 3^3$, in the formation, as 27 quadrilles, which moreover recalls that of dances associated still today with the Chichimecs. Even a glance at texts like the obverse of the Fejervary screenfold, or the reverse of the Cospi screenfold, can leave no doubt about the complexity of Mesoamerican numeracy, in terms of simultaneous reckoning in more than one mode or notation, sheer layout on the page and recurrent ciphers (Brotherston, 1995, q.v. for references to specific codices and native texts).

Two prime numbers not fundamental to the calendar cycles as such (unlike the count of twice 9 Feasts, 9 Night Lords and lots of 13×20 days) yet recurrent enough to merit the epithet ciphers are 7 and 11. Each is a thematically resonant factor in a wide range of exposition.

In the set of nine Night Lords who name and guard each night in unending succession, through gestation periods of nine moons or 260 nights, 7 is Tlazoteotl, the goddess most invoked by midwives and pregnant women; and in the complex sequence in which those same Night Lords guard each year, 7 determines the

rhythm (Borbonicus, pp. 21–22). Of the 13 Heroes, 7 is the lord of our procreated flesh (Tonacatecutli), and figures the inner matrix, which in geopolitics is the tribal homeland known as ‘Seven caves’ in the *Historia tolteca Chichimeca* and the *Popol vuh*. In the emergent body, 7 equals the eyes and other five orifices of the head, explicitly that of the caiman which precedes us as vertebrates (Laud, p. 21; figure 1).

In the set of twenty signs that name the days, 7 corresponds to Deer (mazatl), worth half the carnivorous Jaguar (sign 14; compare the *Popol vuh* hero Jaguar-Deer); and as prey Deer’s skin provides the very surface upon which the scribe may depict the act of writing (compare Borgia Codex, Brotherston, 1995, p. 22, p. 54). In the set of 13 Fliers (Quecholli), 7 is the butterfly (papalotl), the middle hinge yet the most vulnerable, metamorphic, and the only one of the 13 that is not a bird.

As for 11, it has its own non-composite name in Maya (buluc) and may serve as a number base in its own right, along with the more obvious 20 and 10. Its main arena is the night sky, just as number 11 of the 13 Heroes is the Night Lord (Yoallitecutin). As moments along the nocturnal road of the year, 11 seated figures are celebrated in both Laud and Fejervary. Like the prime stellar marker that is the Pleiades, the 11 are pioneers, the trail-blazers. Bearing axes (tepuztli), adepts of the maguey plant and pulque, and adorned with crescent moons, they relate thematically to the first house-builders in the *Popol vuh* who, drunk on pulque, rose into the night-sky to become the Pleiades, and first signposted the road of the year, at one of its two intersections with the Milky Way. The maguey which possesses its own fermenting agents matures over 11 years (also the sun-spot cycle) and 11 is the number of days in the yearly epact of the moon, whose phases affect the amount of liquid carried in the maguey plant. As ‘the place of the axe’ surrounded by 11 hill shrines and tributary subjects, Tepoztlan is home of Tepuztecatl, president of 11 axe bearers from towns along the Chichinautzin-Popocatepetl ridge, who include the maguey and pulque goddess Mayauel and her consort Patecatl, expert in herbs.

The astronomical nature of the 11 is further confirmed by the fact that they preside over formulae relevant to the synodic and sidereal cycles of the sun, moon and the wasp-star Venus, that have their equivalent in the Maya hieroglyphic books (notably the

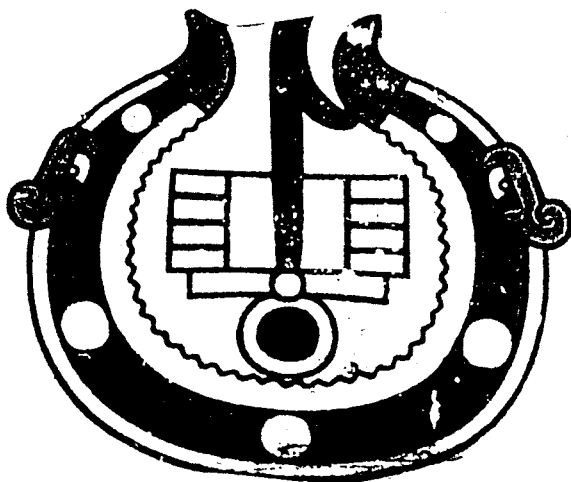


Figure 1. Seven Caves (Laud p.21).

octaeteris formula: eight years less eight days=five Venus years less five nights=99 moons less nine nights). This link is epitomized in the Cempoala murals, where sun, moon and Venus, the brightest bodies in the sky, are numerically correlated and where the moon has inset into it the 11 fold hallmark. In both Cospi and Fejervary, under the aegis of the 11 seated figures, these formulae are in turn calculated in units whose optimal number-base itself is eleven, and which favour eleven as its square (11×11 ; figure 2). As axe-bearing pioneers, the Eleven also appear in Laud, and in a double sequence, prefigure totals of conquests and garrisons listed in such historical sources as Mendoza, the Tlaxcala Lienzo, Tochpan Lienzo 1 and the great stone cuauhxicalli of emperor Tizoc. As if to affirm the link with the night sky, Laud and Mendoza begin their 'upper' sequences with a star glyph.

Various as these occurrences and functions of the primes 7 and 11 may seem at first sight, especially from outside the culture, it is possible soon to sense a certain underlying conceptualization for each. For example, 7 might be to earthly gestation as 11 is to the sky, might be lower as 11 is upper, inner as 11 is outer, female as 11 is male, and so on. Yet in so conceptualizing we cannot be too careful in wishing to avoid the western

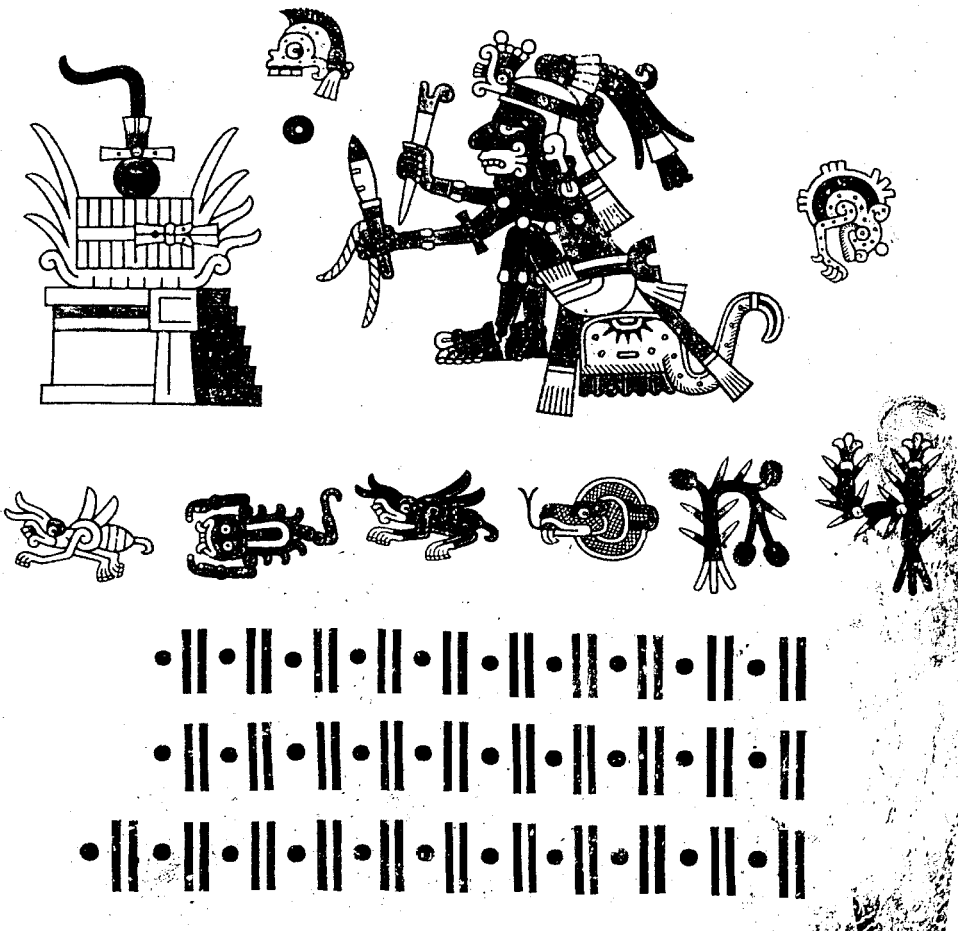


Figure 2. The first of the eleven seated figures (Fejervary p.5).

binomial imperative. For, in context, each occurrence of these numbers is too site-specific, too rooted in particular arguments, to be so lightly abstracted or generalized. The truth that either carries in any given case has too high a density or specific gravity: as we noted, even in quantitative logic, seven within 13 can clearly never be the ‘same’ as seven within nine. In tribute literature, the glyph of a given commodity typically of itself denotes the frequency, in the 18 Feast cycle, with which it is due: by the same token, a powerful semantics inheres in figures and characters that are (also) numbers. The eleven who stride across the pages of Laud will clearly always appear more aggressive than their 11 seated counterparts in Fejervary and Cospi; and these in turn remain more visibly armed and threatening than their toponymic garrison equivalents in Mendoza. Associations may be perceived, equations stated and mathematical principles deduced, yet all without any need for some overarching notion of truth; indeed, if forced on to the text in all its iconic complexity, such notions of truth may actively obfuscate.

This aligns well with what is said in Mesoamerican texts that deal explicitly with questions of truth, the bases and validity of knowledge. A classic and much-quoted example are the Nahuatl accounts of skills gathered by Sahagún in the 16th century that range from those of the feather-worker and lapidary to those of the teacher and philosopher sage (Maffie, in press). Typically, the right or correct way in any one practice is defined through contrast with its opposite, the work of the good and the bad carpenter, for example, or that of the good and the bad scribe; and in this the term *nel-li*, which some have wanted to translate as truth, opposes all that is slippery, untrustworthy, or outright mendacious. Yet in every usage, *nel-li* in fact corresponds less to some overriding western notion of that name than to ideas of confidence and responsibility, and of meticulous care: the knower is the one who knows the road, as a guide of guides, who has even travelled beyond death. Being right stems directly from practice, especially in the verbs ‘arrange’, ‘fit’, ‘match’, ‘count’, and the scribe’s apt use of the primary black and red inks (*tilli*, *tlapalli*) that come to mean whole traditions of knowledge. This way understanding certainly does not exclude reflexivity—the philosopher is the one who holds the mirror—but it requires no abstracted definition of truth.

2. *Amazonia*

Corroboration for this reading of truth as expressed in arithmetical formulae and equations comes from another part of tropical America that is all too rarely compared with Mexico: the lowland rainforest of South America, here called Amazonia. Alphabetic texts adequately edited or published only in recent years make for a fuller understanding of this region than that found in Closs (1985). In addition, there exist certain texts in visible language, of a kind formally comparable with the codices, which have scarcely received attention at all in this respect. To be sure, here we find no Mesoamerican calendrics or books; yet it is possible to intuit common definitions of knowledge, shamanic in origin, in all that concerns the numbering and ordering of things, and in this, a similar understanding of truth.

Widely-known in and around his homeland in the Rio Negro, the hero Jurupary (Medeiros, 2001) institutes laws and music, in a narrative that is itself replete with arithmetical and astronomical allusion. Stories of female and male migrations articulate the nine moons, the 8/5 proportion of sun to Venus and notions of

synodic as opposed to sidereal time. Echoes of this tradition can be found further east in *Watunna* (Civrieux, 1980), the Orinoco Carib cosmogony where (as in Maya) 'human' is vigesimal and means twenty, and humans may become five of themselves, like the digits of hand or foot, or work to the power of 400. On the southern watershed between Amazon and Parana, the Ge-Bororo are noted for visual designs, to whose intricate asymmetry Lévi-Strauss has been drawn, despite his binary Structuralist principles (Ribeiro 1980). Quite spectacular in this respect is the evidence provided by the Bororo in the tradition of painted jaguar skins known in their language as *Adugo biri* (see figures 3–7). Little known, these demand detailed analysis in their own right.

The jaguar *Adugo* plays multiple roles in Bororo cosmogony and society. A figure of fun that can be fooled even by a grasshopper (Wilbert and Simoneau, 1983=WS 166), he is also the founding father of the people. Before the arrival of the 'Brazilians', he was the most feared predator and enemy, and yet can be lover and kin. Intensely telluric, he travels through the sky, and has an undeniable astronomical dimension (Fabian, 1992). Involved with all eight clans, he has a special relationship with the 'first' of them, the 'constructors of the village' (Badajebage Xebeguiugue; Fabian, 1982: p. 298).

The logic embodied in the Bororos' relationship with *Adugo* underlies many of their rituals and ceremonies, most of all the celebration known as *Barege Ekedodu*. Described at length in the *Enciclopédia bororo* (Albisetti and Venturelli, 1962–76, 1:229ff), this 'feast of the wild' is staged to honour the hunter who kills a jaguar single-handed, as a way of compensating the relatives of a Bororo who has recently died. It involves feasting, women and men dancing in pairs, songs sung in honour of the jaguar, and the elaborate decorating of the inner surface of its skin. Held at a 45 degree angle, the painted skin is then paraded along the east-west path that separates the moities of the

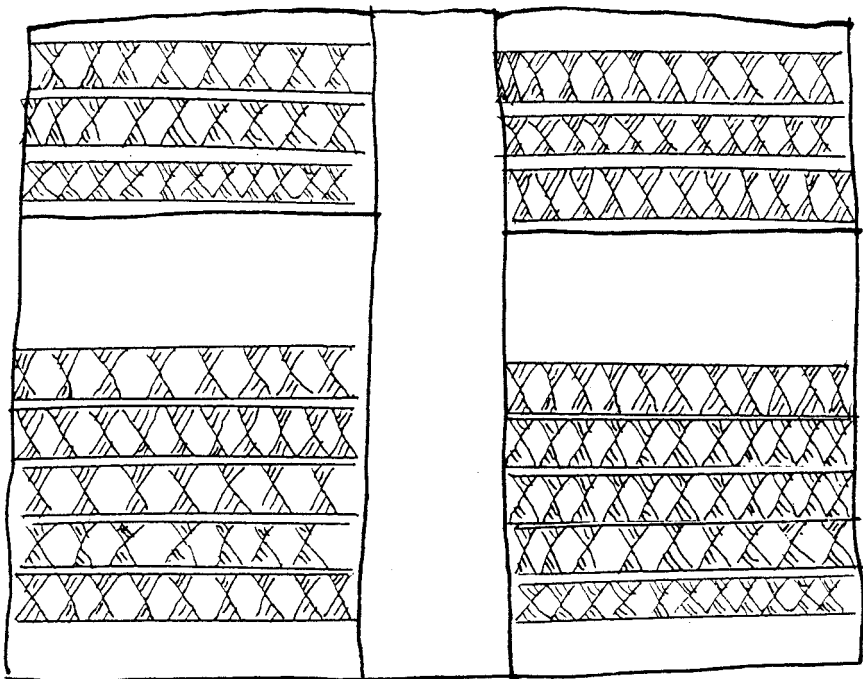


Figure 3. The schema of the Kogaekogae skin.

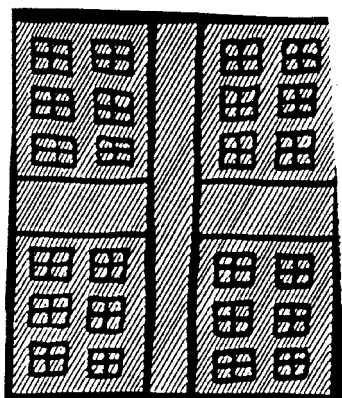


Figure 4. Aije *adugo*: a) source of glyph unit in jaguar fur b) typical Adugo biri of Aije type.

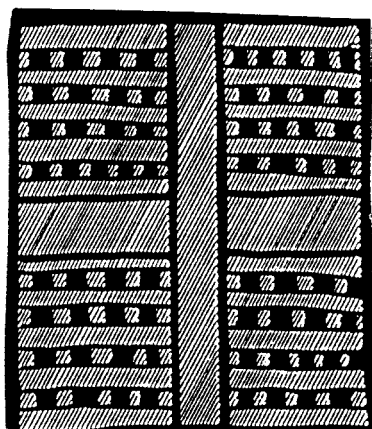
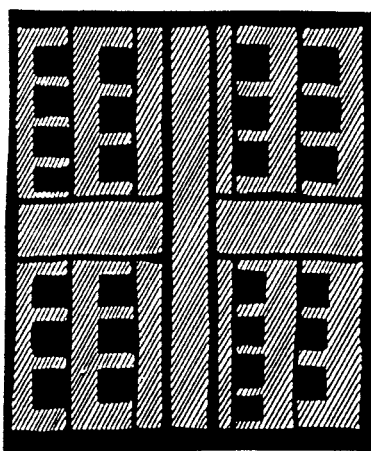


Figure 5. Feather and carapace: a) Aroe eceba oiaga (eagle) b) Ato (turtle).

settlement, and kicked from behind. It becomes the focus of the song ‘Animal skin that speaks’ (Barogo biri batarureu) which plays on the multiple significance of the jaguar *adugo*.

The skins prepared for this ceremony are the *Adugo biri*, a term which means both ‘jaguar skin’ and ‘painted skin’. The designs on the inner surface are normally drawn, with the finger and the aid of a ruler, in two colours, red and black, obtained from urucu or achiote dye (*nonogo*) and charcoal (*irogodu*). This pair of colours, red and black, is used to distinguish between the Bororo subclans and is said to have adorned the skin, when new-born, of *Adugo*’s twin sons, the *Bakororo-doge*, who guard the west and east entrances of the settlement. The format characteristic of the *Adugo biri* designs is a central column with glyph-like units arrayed to either side, which, physically highlighted in the *Barege Ekedodu* parading of the skin, effectively correlates vertebrate anatomy with the east-west layout of the Bororo settlement. In so doing, it comes brilliantly to exemplify Bororo notions of bodily and social reconstitution.

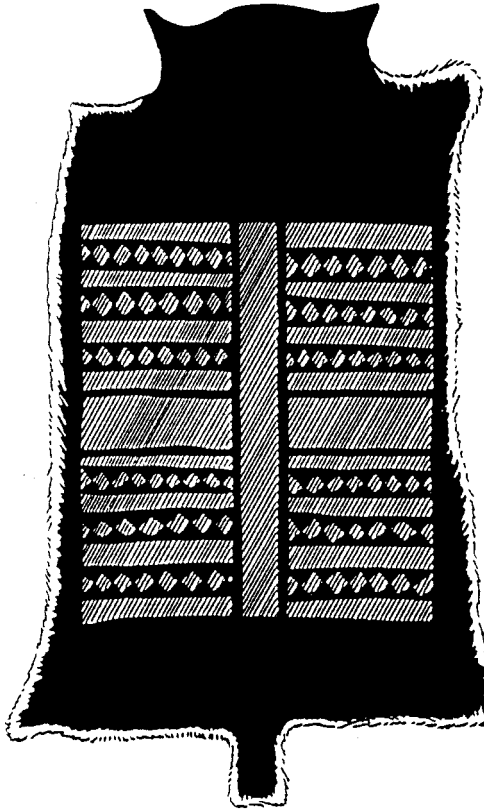


Figure 6. Buregodurege edugo.

Listed as eleven, in alphabetical order, in the *Enciclopédia bororo*, the actual Adugo biri designs are minutely classified in terms of provenance and clan affiliation. Several fall into obvious pairings with respect to skin-cover source and type of patterning. They are all defined by one or other of two suffixes which, though phonetically close as *atugo* and *edugo*, point to categorical difference. Of the 11 listed, eight belong to the first category and three to the second.

atugo: Aije, Aroe eceba oiaga, Aroia, Ato, Bokodori bo*, Enogujeba, Kurugugwa oiaga, Okoge bakororo

*in two colours, red and black (coreu akirireu & kujagureu)

edugo: Burego dureuge, Iwara arege, Kogaekogae doge

Heading the *Enciclopédia* list of designs in the first category (*atugo*) is the Ai-je, which adorns the vibrating musical instrument of that name, the ‘bull-roarer’ (*zunidor* in Portuguese), and it belongs to the Aroroe clan. Its unit consists of a rounded square with an inner fourfold division, quite in the style of a Maya hieroglyph, said to represent the markings on a jaguar skin (figure 4). It is read as the monstrous roaring sound produced by the instrument in imitation of a large feline (*ai-*). Socially, the fours recall the 4+4 clan structure of the Bororo settlement, to either side of the sun’s east-west path, and (in the example given in the *Enciclopédia*) the more complex

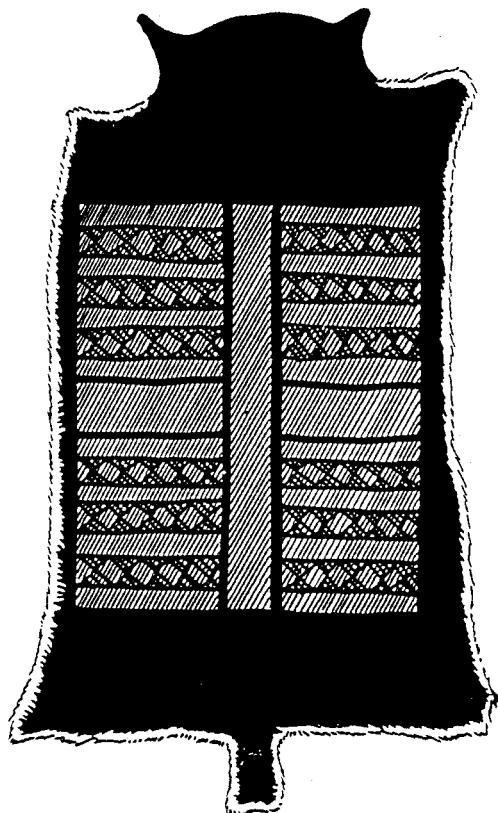


Figure 7. Iwara arege edugo.

12+12 arithmetic of the sub-clans. In similar fashion, the Aroia design derives (etymologically at least) from textiles and in fact interweaves, in decidedly textual fashion, both *atugo* and *edugo* motifs.

The remaining six designs that have the *atugo* suffix fall readily into three pairs, in terms of both form and zoological origin. The tail feathers (*oiaga*) of the Aroe ecceba or Xerae (harpy eagle) and the Kurugugwa (caracarai hawk), the pair of predators proper to the Apiborege clan who helped Adugo banish sun and moon from the sky, are defined in flag-like units that laterally invert left to right, fall into upper and lower halves (figure 5a), and may intimate the principle of diagonal correspondence also basic to the placement of clans and sub-clans within the settlement. The pair of feathered birds is complemented by the carapaced turtle and armadillo (Ato, Bokodori), and two scaly fish (Enogujeba, Okoge). The designs characteristic of each of these further pairs are no less susceptible to the same order of logical and arithmetical analysis, especially the armadillo whose clearly-defined body bands prompted the latinized epithet 'novemcincta' and serve to align countable units horizontally (figure 5b). Together they invite us to explore the story common to the vertebrate life-forms whose boundary with the world is scale, carapace, feather and, first and last, the fur of the singular jaguar.

The three Adugo biri designs that have the *edugo* rather than *atugo* suffix stand out visually as different from the first. They all have glyph-units that consist of a vertical

pair of isocetes triangles touching at their apexes, which gives them an 'X'-like appearance, and which are arrayed horizontally in rib-like rows (figures 6 and 7). They derive from the body and face paintings of the sky spirits: the Burego and Kogaekogae, who revealed the names of the stars, and the Iwara Arege who 'measure' and tell their identities (WS 51–4). All three belong to the Badajebage Xebeguiugue clan, to whom the star names were revealed.

The three *edugo* designs are distinguished one from another by the type of triangles they respectively have. The Burego triangles are solid, while the other two types are hatched. In the Iwara Arege design this hatching normally runs along the diagonal formed by the two triangles from lower right to upper left (\); in that of the Kogaekogae it runs along one or other diagonal (\, /) (Figure 8a,b).

According to the *Enciclopèdia*, the Bororo have mutually non-exclusive explanations of what the Barege Ekedodu ceremony means, and of the particular significance of the Adugo biri within it (EB 1:235). These explanations belong to shamanic modes of thought, or philosophical traditions, identified in that source by the terms *bari* and *aroe*. The former emphasizes the bargain made with the sky spirits that there be more jaguars to hunt, the beast feared yet desired as anagnorisis. Fully in line with Bororo ideas of reconstitution, the *aroe* version points rather to the material skin that will clothe and protect the soul on its journey beyond death, that will indeed re-embody and re-articulate that soul, complete with teeth and claws, necklace and crown. In the ceremony, the one who hangs the skin from his neck also wears the jaguar's teeth and claws. Hence the visual and numerical interest evinced by the Adugo biri corpus, in the longer story of the vertebrate body and its coverings. Likewise, the central column and anatomical format recall the body-frame thanks to which Meri the sun was able physically to reconstitute his brother the moon Ari, after the latter had been torn apart by Adugo.

Further insight into just these Bororo notions of precedent, numerical and conceptual, is offered in the accounts of how the jaguar became the forefather of the tribe, and how he put the sun and moon to flight. For in his foundational role, Adugo both engenders the hero Twins known as the Bakororo-doge, who clear for the Bororo their space on earth, and matches himself against the celestial bodies of the sun-moon (Meri-doge), and the stars. These stories are told in two sequences, which belong respectively to the terrestrial and celestial registers, and intricately cross-reference.

The first narrative (WS 174–86) concerns the role of Adugo as father of the hero twins Bakororo-doge (Bakororo and Itubore), who rid the world of excessively dangerous beasts. Adugo's wife is the daughter of the Bororo hunter Akaruio Bokodori, of the Badajebage Xebeguiugue clan, who instituted the feasts held in honour of jaguars (WS 110–1). In marrying Adugo, she inverts Bororo matrilocal custom by travelling to her husband's home. This home is named by him as the last of a series of seven caves, and she takes seven nights to get there, sleeping with the occupants of each of the previous caves along the way. Feline (note the *ai* element discussed above) and wolverine, each occupant has progressively less black in his skin, the jaguar having the finest and most variegated skin of all:



Figure 8. Double triangle or 'X' units: a) Iwara arege b) Kogae kogae c) variant of b) d) variant of b).

- | | |
|--------------------------|--------------------------------------|
| 1 Ipocereu (black tayra) | 2 Ai meareu coreu (black forest cat) |
| 3 Okwa (small wolf) | 4 Rie (big wolf) |
| 5 Aigo (puma) | 6 Aipobureu (jaguatirica) |
| 7 Adugo (jaguar) | |

Numerically, and set in pairs as they are, the caves or holes explored by Adugo's bride correspond to the head orifices – the sites of the senses (ears, eyes, nostrils) that she needs fully to identify her future husband, the 'speaker' and owner of the singular mouth (commemorated in the Barege ekedodu song of the 'onça falador'). Moreover, in the classic proportion 7/9, the orifices of the whole body might be insinuated in the penetration of Adugo's bride that goes on in the caves, first thanks to his predecessors, who do not inseminate, and then to him, who does.

The other narrative about the jaguar Adugo (WS 55–6) casts him as the first of 11 creatures, rather than the last of seven, again all vertebrates, who encounter the powerful figures of sun (Meri) and moon (Ari), known jointly as the Meri-doge. These two, sun and moon, have many dealings with jaguars, and each is owner of a decorated jaguar skin made by the other (WS 42). In the story of the eleven creatures, Adugo is attacked by the Meri-doge luminaries for having once devoured the moon, an act which obliged the moon's brother, the sun, to reconstruct his body from the remains laid out on a framework anatomy (WS 24–7). The restitutive powers displayed by Meri in this regard enable him elsewhere to endow humans and other creatures with body parts, including teeth and digits.

In being attacked and put to flight, the jaguar Adugo is specifically identified as the father of the Twins, those who guard the horizons between which Meri-doge are here said to be travelling on their celestial journey. The first three of the eleven creatures that Adugo leads are himself plus two of the four feline cave-dwellers who knew the Twins' mother before he did, an inversion of sequence. There follow six birds, including the eagle-hawk pair commemorated in the Adugo biri, and the heron 'night lord', a known constellation. Then, finally, comes the pair monkey and caiman, designated as 'upper' and 'lower', the caiman (Uwai) also being a constellation. Put to flight, each of the eleven is commemorated in turn in the verse of a song, in subgroups marked by pauses:

1 Adugo; jaguar

- | | |
|--------------------------|---------------------------|
| 2 Aipobureu; jaguatirica | 3 Aigo; puma |
| 4 Kurugugwa; hawk | 5 Aroe Eceba; harpy eagle |
| 6 Toroa; sparrow hawk | 7 Baruguma; little hawk |
| 8 Bace; heron | 9 Kidoe; parakeet |
| 10 Aroe pai; monkey | 11 Arogwai; caiman |

In both stories, Adugo appears with other vertebrates in sequences that involve counting and numerical logic. As the last and then the first, Adugo is singular in each case, in what otherwise tends to be an enumeration in pairs. Then, for their part, these pairs form subgroups according to shifts and pauses in the narrative, and to what we know or are told, here and elsewhere, about their skin covering, diet and habits, and the taboos that govern the hunting of them. Among the 11, the three felines and the subsequent three pairs of birds constitute a subgroup of nine, to which the final pair, after the shift in location, is added as a kind of coda: the egg-laying caiman and the near-human monkey, 'low' and 'high' in the vertebrate story. As we saw, skin covering (scale, feather, fur) is a principal source of the Adugo biri designs.

3. *Embodied arithmetic*

Deriving as they do from a range of natural phenomena and conventionalized social indicators, the Adugo biri designs constitute what demands to be acknowledged as a textual corpus, a series of visual statements that are framed and reflexive and which intricately cross-reference. Whatever their natural origin may be or have been, the glyph units ranged in them demand to be counted arithmetically in their own right, in sets and groupings that are predetermined by the particular format, and which vary from ceremony to ceremony. In this process, there is an obvious play with expectation, in the sense of introducing a variant into an otherwise symmetrical pattern, and with styles of counting, serial and cumulative, and with squaring and multiplication generally.

For example, the Aroe eceba oiaga design that reflects the tail markings of the harpy eagle sets its units either side of the middle column, and in upper and lower areas. Facing left, the units to the left mirror, i.e. laterally invert, those to the right, which face right, and thereby affirm a pattern of diagonal correspondence, upper left to lower right, and upper right to lower left. Yet upon inspection the mirroring proves to be not quite symmetrical, since in the former of the two diagonals the inner vertical line becomes the outer (or vice versa; figure 5a):

	left	right
upper	4 3	3 3
lower	3 3	4 3 [i.e. not 3 4)

Again, the turtle's carapace *Atu atugo* (figure 5b) establishes a norm of four units in each of four rows in each of four areas (i.e. $4 \times 4 \times 4$ or 4^3), only then to modify it in three of the areas—upper left and right, lower right—through the addition of an extra unit in one of the rows (fourth, first and third respectively):

	left	right
upper	4	5
	4	4
	4	4
	5	4
lower	4	4
	4	4
	4	5
	4	4

This kind of logic is taken further in the arrangement of X units in the Iwara arege design (figure 7), where the reading is horizontal, across pairs of ribs, three in the upper area and three in the lower. The left side is quite regular, and proposes a pattern of three fives, upper and lower; and the right side is irregular, since two of the six ribs there increase this number to $5\frac{1}{2}$ and another two ribs increase it to 6:

	left	right
upper	5	6
	5	6
	5	5½
lower	5	5
	5	5½
	5	5

This means that the lowest total on any one rib is five and the highest on any pair is 11. These term numbers are then seen to be developed, to left and right respectively. The fives to the left are counted cumulatively, in sigma style, to give twice 15 (1+2+3+4+5). Meanwhile, the right half produces half the sigma count of the higher number, 11. The sum of the two halves is 63, the product of seven and nine, the intervening odd numbers between 5 and 11. Hence:

$$\left. \begin{array}{l} \text{left : } 2(5 \times 3) = 30 = \sum 5 \times 2 \\ \text{right : } 2(5 + 5\frac{1}{2} + 6) = 33 = \sum 11 \times \frac{1}{2} \end{array} \right\} = 7 \times 9 \quad (1)$$

Beside having a clear elegance in its own right, this formulation invokes ciphers resonant in Bororo culture. The fives to the left are the digits of the hand and foot that Meri formed for earthly humans; the 11 to the right are the bodies led by Adugo that Meri chased from the sky. The intervening seven and nine correspond to the orifices of the human head and body.

In a Kogaekogae skin now in Vienna (Kann, 2000, figure 3), logic and arithmetic follow the same lines, and there are even coincidences between actual totals and number-groups of units (notably the prime number 11), and between the styles in which they are added (serial, cumulative) and multiplied. Yet this Kogaekogae design is far more complex, thanks in part to its characteristic use of two kinds of differently-hatched X units. Also, here there are eight rather than six pairs of ribs (three upper, five lower), and larger totals that range from seven on a single rib to 22 on a pair. There are even variant forms of the X unit, and a fraction that is less than half.

Starting with format and distribution of rib totals of X-units, regardless of which type they are, the following Number-Group scheme of integers can be established:

ribs:	totals of X units:	
	left	right
upper A	8	10
B	9	11
C	11	11
lower D	8	11
E	10	11
F	7	11
G	7	9
H	9	11

Through simple addition, the grand total of all X units on the 16 ribs is 154. That neither this number nor the framework design is random is immediately suggested by two concomitant formulae. First, the total of the highest and most populated number group, 11, exactly equals that of all the other numbers put together:

$$(7 \times 2) + (8 + 2) + (9 \times 3) + (10 \times 2) = 77 = 11 \times 7 \quad (2)$$

Second, the grand total is the product of the lowest total on any one rib (left F or G) multiplied by the highest total on any pair of ribs (C):

$$7 \times 22 = 154 \quad (3)$$

In both equations, the main factors are the prime numbers 7 and 11, which serve as lower and upper terms for the full flush of five numbers 7,8,9,10,11, being the only primes in that range. With respect to the skin's material source, they are of course precisely the two primes we saw operative in the Adugo stories of the caves and the sky respectively.

Their clear conceptual resonance in these cases may encourage us to consider in similar terms the intervening numbers, even (8, 10) and odd (9), and further to explore the notion of numerical construction as such, in the prolonged analogy between numbers with their factors and the body with its parts.

Coincident with the format itself (the eight rows of ribs), 8 indicates the number of clans in the Bororo settlement. Doubled to 16 (left A and D) in the binary progression for which Bororo logic is renowned ($2 \dots, 2^3, 2^4$), it also brings anatomy into play. For in the Barege Ekedodu ceremony, the person who bears the jaguar's skin is also adorned with its teeth and claws, tokens of the body which in the *aroe* reading of the ceremony is to be protected and even reconstituted. Multiplying in pure binary progression in the human adult, teeth reach just the total established in the upper right area, that is, 32, or 2^5 . (For good measure the total of teeth in a child's mouth, 28, is given in the matching area upper left). As for the human equivalent of the claws, they are correspondingly specified in the other pair of even numbers, the 10s (right A, left E). When strengthening the beaks of birds, Meri goes on to endow humans with their binary sets of teeth, and their decimal sets of fingers (WS 155). Thanks largely to the Bororo, binary logic became the basis for Lévi-Strauss's structuralism; as for decimals, digits form the base of Bororo counting nomenclature (Fabian, 1992, p. 232).

Just as the even numbers correspond to projections of the human body, so the odd number 9 corresponds to its orifices and stands in a special ratio to the seven of the head orifices. Indeed, just as in the Iwara arege design examined above (1), 9 and 7 here multiply to produce the sum of the intermediary divisible numbers:

$$(8 \times 2) + (9 \times 3) + (10 \times 2) = 7 \times 9 \quad (4)$$

Finally, the question of surface and dimensions, and how it may relate to the other equation stated above: 7 (lowest total on any one rib) \times 22 (highest total on any pair of ribs) = 154 (grand total). When the Adugo biri skin is placed on a human body in the Barege Ekedodu ceremony, its inscribed ribs undergo a lateral inversion: what is left and right for the observer becomes right and left for the wearer. At the same time, the pairs of ribs inscribed on the flat two-dimensional surface curve protectively around those of the wearer. Given the coherence of the arithmetical statement made by the grid design so far, along with the concept of this inversion, it is perhaps not too bold to recall that the formula shown above to produce the grand total of units, $7 \times 22 = 154$, can correspondingly be inverted. For, expressed as $\frac{22}{7}$, or π , it produces

a rounding of the ribs into the third dimension, shaping them into the cylindrical thorax shield. An equivalent argument is proposed by Fabian when he speaks of ‘squaring the circle’ of Bororo space-time (1992, p. 163).

4. *Cross-matching*

The analysis made so far of the Kogaekogae text has been entirely based on number groups, on the sheer grouping and distribution of X units within the rib format, without regard for the type of X unit involved. The next stage means distinguishing between the two types of unit it uses, those whose hatching points upwards to either left (=X\) or right (=X/; figure 8b). From the start, we may confirm that, although they are intricately distributed between the number groups and to left and right in the upper and lower areas (as we shall see), each of the two types of hatched X unit totals 77, in an exquisite complement to the Number-Group formula established above (see 2):

$$\begin{aligned} X/ : & 7 + 8 + 9 + 10 + 10 + 11 + 11 + 11 = 77 \\ X\ : & 7 + 8 + 9 + 9 + 11 + 11 + 11 + 11 = 77 \end{aligned} \tag{5}$$

Overall, the general direction of the hatching in the units (on the exceptions, see below) corresponds to their respective positions on the ribs to right and left in the upper and lower areas, in the diagonal cross that echoes that of the X unit itself.

	left	right	
upper	X\	X/	i.e. \ /
lower	X/	X\	/ \

Introducing a subtle variation, the hatching in one of the five ribs in each of the lower areas fails, however, to cross-match with that of the three in the respective upper area, right to left and left to right, in the pattern established by the X design. The exceptional fifth ribs (left G, right D) highlight the primes 7 and 11, again, and in so doing implicitly associate the X\ unit with seven and the X/ unit with eleven.

ribs:	totals of X units:	
	left	right
	\	/
upper A	8 *	10 **
B	9	11
C	11	11
	/	\
lower D	8	/11
E	10	11
F	7	11
G	\7	9 *
H	9	11

* the two outermost X units have inverse hatching in lower and upper triangles respectively

** beginnings of a further X unit innermost (Fig.8c,d)

The association between the two types of X unit, on the one hand, and the primes 7 and 11, on the other, is in fact developed in the actual totals of these units found in the upper and lower areas, diagonally to left and right. For the totals of X\ units to upper left and lower right relate to both the square and the sigma count of the smaller main prime, 7. Completing the pattern, the X/ totals to upper right and lower left give the sigma count of the larger main prime, 11, reaching that total again via squares, and multiples to the power, of all the smaller primes (2,3, 5), as well as the sigma count of the intervening 9. Always adding only like with like, strictly within the four areas of the grid this produces:

X/		
left	right	
upper: 28=Σ7	—	
lower: 7	42	=7+42=49=7 ²
all:		Σ7+7 ² =77=7 × 11
X/		
left	right	(6)
upper: —	32=2 ⁵	
lower: 25=5 ²	11	
+9=3 ²	—	
=34	11	=34+11=45=Σ9
all:		34+32=66=Σ11+11=77=11 × 7

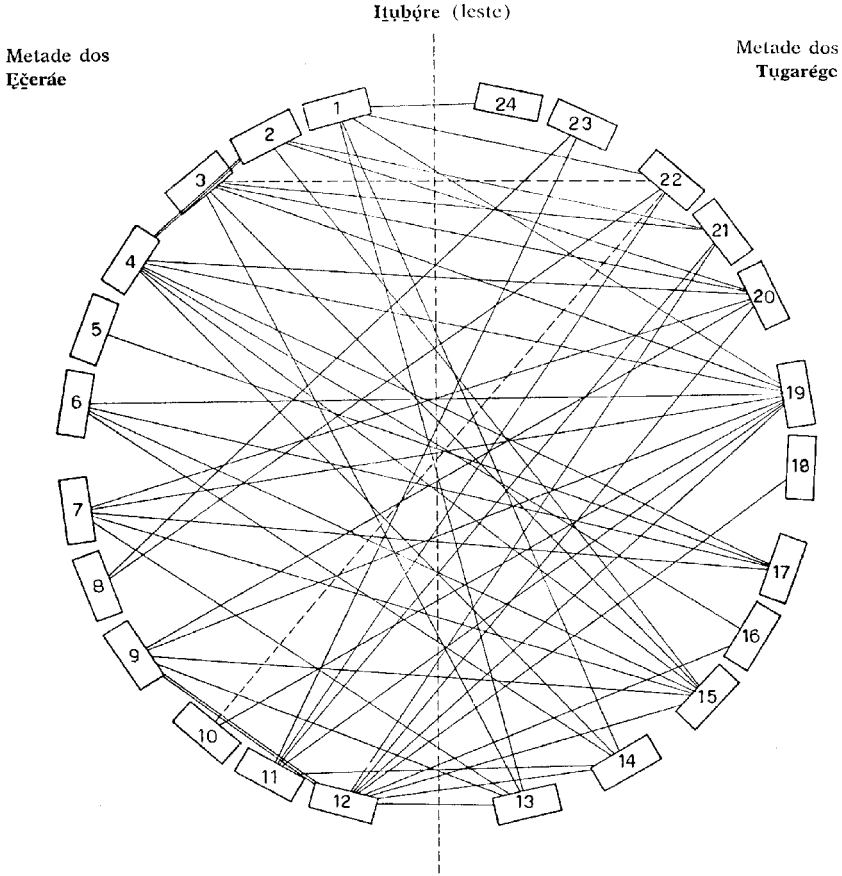
In other words, the disposition of the two types of X units complements the number-group disposition at every stage. What it adds is the notion of cross matching, explicit in the hatching in the two types of units themselves, and which Reichel-Dolmatoff has convincingly related, at one level, to tropical American notions of gender relations between male and female, and human procreation (1981, p. 22). In social terms, it may be usefully compared with the layout and exogamy of the Bororo village, whereby the Xera and Tugarege moieties to north and south are each divided into lesser and greater parts, creating the possibility of more intricate cross-matching (figure 9). Finally, it becomes the means for expressing the arithmetic of the sky also inherent in this superb example of an Adugo biri.

5. *Bodies of the sky*

The Kogaekogae type of Adugo biri identifies those who named the bodies of the sky. For that reason, its complex arithmetic might be expected to invoke those bodies, no less than terrestrial anatomy and clan. Thanks to the work of Fabian and others, there can be no doubt about the sophistication of Bororo astronomy as such.

Guarded by Bakororo to the west and Itubore to the east, the very axis of the Bororo village commemorates the ‘sun’s path’ (as it is called, Meri etawara; WS

ESQUEMA DAS UNIÕES MATRIMONIAIS



Linha cheia: uniões preferenciais
 Linha interrompida: uniões toleradas
 Linha dupla: uniões lícitas entre membros da mesma metade

Sub-clãs da METADE DOS EÇERÁE:

- 1. Baádo Jebáge Çobugiwúge Çobugiwúge; 2. Baádo Jebáge Çobugiwúge Bóe E-ladađawúge;
- 3. Baádo Jebáge Çobugiwúge Çebegiwúge; 4. Bòkòdóri Eçeráe Çobugiwúge; 5. Bòkòdóri Eçeráe Bóe E-ladađawúge;
- 6. Bòkòdóri Eçeráe Çebegiwúge; 7. Kíe Çobugiwúge; 8. Kíe Bóe E-ladađawúge;
- 9. Kíe Çebegiwúge; 10. Baádo Jebáge Çebegiwúge Çobugiwúge; 11. Baádo Jebáge Çebegiwúge Bóe E-ladađawúge;
- 12. Baádo Jebáge Çebegiwúge Çebegiwúge.

Sub-clãs da METADE DOS TUGARÉGE:

- 24. Páiwçe Çobugiwúge; 23. Páiwçe Bóe E-ladađawúge; 13. Páiwçe Çebegiwúge; 22. Api-
 bórége Çobugiwúge; 21. Api-
 bórége Bóe E-ladađawúge; 20. Api-
 bórége Çebegiwúge;
- 19. Arórçe Çobugiwúge; 18. Arórçe Bóe E-ladađawúge; 14. Arórçe Çebegiwúge; 17. Iwagúdu-
 dóge Çobugiwúge; 16. Iwagúdu-dóge Bóe E-ladađawúge; 15. Iwagúdu-dóge Çebegiwúge.

Figure 9. Clan cross-matching (EB 1: 450).

95), travelled by the sun, moon and planets. Over the course of the tropical year, the sun, the brightest of them all, rises and sets, to north and south along the east and west horizons, in positions likewise commemorated in the layout of the Bororo settlement (Fabian, 1992, p. 163) and, in the case of the June solstice, in the bonfires of the male initiation ceremony Akiri doge. When viewed in plan,

the solstice pattern, widely recognized in tropical American astronomy, is also reflected in the very design of the *edugo* 'X' unit. The central or midday moment as such is specified in 'Adugo's bride', when Adugo wrestles with his future father-in-law from dawn until exactly noon:

	northern solstice	southern solstice
sunrise	x	x
	village/noon	
sunset	x	x

Reading the X units as years, on these grounds, alerts us to the unique and striking status of one of the eight rib rows (D). Unlike any other (G includes variant Xs), it has X-units whose hatching always goes in the same direction (X/), on both the left and the right sides. It reads:

$$8 + 11 = 19[\text{years}] \quad (7)$$

The formulation could hardly be more resonant in terms of Meri, the sun, and the solar-lunar entity Meri-doge, Adugo's antagonist. For the synodic cycles of sun and moon first coincide after eight solar years or the octaeteris, which equals 99 lunations (plus almost one night). A yet more exact coincidence occurs after 19 solar years or 235 lunations, the so-called Metonic cycle which in Christendom still serves as the arithmetical basis for calculating the date of Easter. In the Kogaekogae design, the first cycle is incorporated into the second (Metonic) cycle as $8+11=19$.

As the cipher of the sky jaguar, the eleven mediates, in years, between 8 and 19; in moons, it is a factor of the octaeteris, which amounts to 11×9 moons (traditionally, eleven periods of human gestation); and in days it is the epact.

With its clear astronomical significance, the Kogaekogae text may yield further such formulae when analysed in yet more detail, relevant to the sidereal moon and, possibly, Mercury.¹ For now it is enough to reaffirm that it demands more recognition as a visual text than it has received hitherto. Deploying and correlating numbers with considerable sophistication, it embodies paradigms of Bororo culture, while its very format and patterning of variables prompt the desire to understand and decode. That it might be just random as a numerical statement is rendered impossible by the series of interlocking equations involving number groups and the two types of X unit (equations 2, 3, 5).

The 'decoding' of the Adugo biri corpus is best done in the terms the texts themselves propose, as the skin of an animal which plays a foundational role in the terrestrial and celestial registers of Bororo cosmogony, and which features pre-eminently in the Barege Ekedodu ceremony during which such painted skins are made, paraded and worn. In this way, meaning inherent in the actual performance of the ceremony can be correlated with the key jaguar narratives. This correlation highlights a logic which is in part but by no means exclusively binary, and an order of numeracy not normally associated with lowland South America. Pertinent to the attempt to understand human cultural history, the Adugo biri text raises questions of epistemology, of integral reading, while its meaning depends on complementary local schools of Bororo philosophy (*biri*, *aroe*) neither of which could ever claim to possess absolute truth.

6. *In sum*

In the comparative view, arithmetical statements found in the codices of Mesoamerica and the Adugo biri corpus of Amazonia prove to have a striking affinity. Shared features include black and red notation on a skin surface; meticulous attention to format and spatial layout; modes of counting (serial, cumulative, to the power); numbers that have multiple embodiments and broadly similar semantics; among these, the privileging of ciphers, notably the primes 7 and 11. In terms of cultural history, these coincidences are remarkable, especially given the great distances in time and space that separate the two traditions. In the present argument, yet more critical is the fact of a common resistance to generalized and abstract notions of truth. Knowledge lies rather in the valency of numbers arranged, configured, embodied and lived.

Notes

1. When each constituent triangle is taken as a unit, the layout of X\ (and variant X\ in left A, right B) produces the total of nights in three sidereal moons ($27.3 \times 3 = 82$); in the same count, the number group 11 or 22, together with the incipient X unit in right A, suggests two sidereal cycles of the 'moon's companion', in innermost planet Mercury (see Brotherston, in press).

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