# Weaving Symmetry of the Philippine Northern Kankana-ey

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## Abstract

This paper will discuss the indigenous mathematical concept of the weaving patterns on the fabrics of the Northern Kankana-ey in the Mountain Province, Philippines. This study examines the use of mathematical symmetries and color symmetries in various Northern Kankana-ey fabrics.

## Introduction

The Kankana-ey is a cultural group in the Cordillera region of northern Luzon, Philippines. The term "Kankana-ey" refers to both the people and to their culture and language. There are two Kankana-ey groups: the Northern Kankana-ey who inhabit the southwestern part of Mountain Province and the Southern Kankana-ey who inhabit the northern part of Benguet. Both northern and southern Kankana-ey are rice-terracing agriculturists on the high slopes of the central Cordillera range and they appear to have existed long before the coming of the Spaniards to the Philippines. Proof of this is the extensiveness of their rice terraces. They raise rice as staple food and for rice wine brewing. There is no record of their history until the arrival of the Spanish colonialists in 1570's. The Spaniards found the people were independent farmers, much as they are today.

**Figure 1**: *Northern Kankana-ey* [8].

In [4], weaving according to unpublished archeological field reports, "emerged" in the second millennium B.C. in the archipelago now known as the Philippines. This was supported by conical and biconical spindle whorls found in Arku Cave in Peñablanca, Cagayan, northeast Luzon. According to [5], textile weaving having been borne and nurtured in the economic activity that is agriculture has design patterns and motifs associated with rice cultivation and its attendant belief system and religious practices. This traditional weaving skill of the Kankana-ey women, which they used to do after farming breaks, is called body-tension back strap weaving and locally called *impaod*/*impagod*/*pinnagod* which means "strapped". They fasten around their waist a back-strap loom with a warp of threads whose ends were attached to a post or a tree and would begin weaving. Their main source of the colors transferred to the fibers for weaving are different plant species in their surroundings.

**Figure 2**: *Body-tension back strap weaving.*

The designs on fabrics, which we will study and analyze in this paper, belong to the northern Kankana-ey, who have preserved their indigenous culture and are governed by centuries-old traditions and practices up to this day. From here on, we will use the term Kankana-ey to refer to the northern Kankana-ey. The Kankana-ey women traditionally weave for clothing, for ceremonial use, and for exchange. They weave decorated blankets (*galey* now referred to as *ules*), woman's skirts (*getap* now called *tapis*) and waistband (*wakes* or *bakget*); man's loincloth/g-string (*wanes*) and headcloth (*bedbed*).

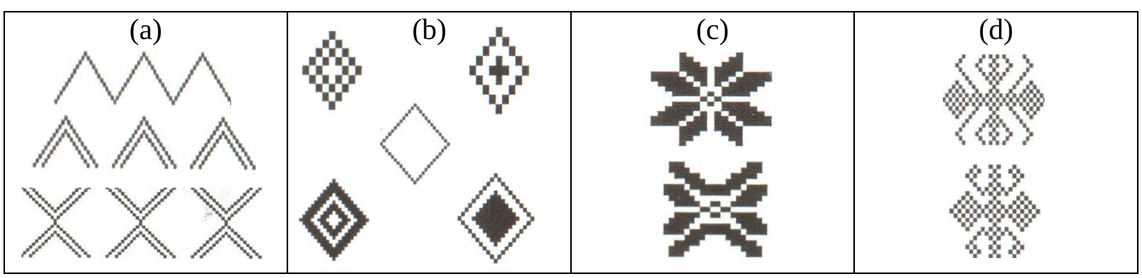



**Figure 3**: *The common designs on the Kankana-ey fabrics*: (a) *tiktiko;* (b) *matmata;* (c) *sopo*; (d) *kulibangbang* [6].

The combination of the common designs, namely *tiktiko*, *matmata*, *sopo* and *kulibangbang* produce the Kankana-ey patterns on the fabrics which we will analyze. As explained in [5], these design patterns and motifs are festive expressions in the celebration of life (the joys, the revelry, attendant to fertility and abundance/bountiful harvest) and also the Kankana-ey's reverence towards their natural surroundings and their harmonious relations with the environment. Figure 3 illustrates these designs and its variations. Their villages, which are on mountain crests and deep valleys, have zigzag designs of *tiktiko* and these zigzag designs have been perceived to depict mountains and forests where their rice fields are located. The X's *tiktiko* and ◊'s *matmata* imply abundance, reverence, awe, and high regard to whatever the X's and ◊'s stand for. These X's *tiktiko* represent rice mortars because they resemble the shape of their rice mortars whether carved in stone or wood. Rice gives their body nourishment and so they admire and revered it like a god that is everywhere and all-seeing, hence the double-lined ◊'s *matmata* are perceived to represent rice grains and the eyes. The combination of X's *tiktiko* and ◊'s *matmata* are expressive of wealth and abundance hence these are designs used exclusively for the clothing material of the rich. Abundance, fertility, and wealth are emphasized on their depiction of flora and fauna where the *sopo* represents a flower and the *kulibangbang* represents a butterfly.

One and two dimensional patterns can be naturally classified according to the symmetries they admit. In our work, we use Washburn and Crowe's flow charts in [7] to determine and analyze the one-dimensional and two-dimensional symmetry groups of patterns appearing on the different fabrics of the Kankana-ey. By a *symmetry* group of a pattern we mean the group consisting of all the symmetries that send the pattern to itself. It is a known result in mathematical crystallography that there are 7 types of one-dimensional or strip symmetry groups (frequently called frieze groups) and 17 types of two-dimensional symmetry groups. In this study, we will focus on the patterns appearing on the *ules*, *tapis*, *wakes/bakget*, *wanes* and *bedbed* because these are what majority of the traditional weavers produce.

## Symmetries of *Ules*, *Tapis*, *Wakes/Bakget*, *Wanes*, and *Bedbed*

**A. The *Ules* and *Tapis*.** The *ules* are used to cover the upper bodies of the Kankana-ey as a protection against the cold. The blanket incorporates red and blue panels of varying widths, with figures of mortars, or some anthropomorphic figures. Children are first given the *ules* for covering when they start wearing their own *wanes* or *tapis*, at age six or seven.

An *ules* or *tapis* is made up of three panels of woven clothing material, namely two identical side panels and a middle panel. The combination of X, Λ (*tiktiko*) and ◊ (*matmata*) are consistently featured on the vertical strip patterns on the side panels of the *ules* or *tapis* as shown in Figures 5 (a), (b) and (c). We have vertical and horizontal reflections that are symmetries of each of these vertical strip patterns. (Figure 6 (a) shows distinct axes of reflections and their intersections as centers of $180^0$ rotations.) Strip patterns such as these, with symmetries consisting of both vertical and horizontal reflections have a symmetry group of type *pmm2*. The horizontal strip pattern, where we have the combination of a zigzag *tiktiko*, *matmata* and *sopo*, in the middle panel of the fabrics in Figures 5 (a), (b) and (d) also have vertical and horizontal reflection symmetries; hence, has symmetry group also of type *pmm2*. Axes of reflections and centers of $180^0$ rotations on a strip pattern are presented in Figures 6 (b), (c) and (d), respectively.

If we consider the pattern appearing in the middle panel on the *ules* and *tapis* as a two dimensional repeating pattern, we usually obtain a symmetry group that is of type *pmm* or *p4m*. For the patterns given in Figures 5 (a), (b) and (d) there are symmetries that consist of vertical and horizontal reflections whose axes are perpendicular. There are also 180° rotations with centers occurring on axes of reflections (For instance, see Figures 7 (a), (b) and (c)). Thus the symmetry group of these patterns is of type *pmm*. For the two dimensional pattern appearing in the middle panel of Figure 5 (c), its symmetry group is of type *p4m.* There is a $90^o$ rotation and reflections with axes that intersect at $45^{\,o}$ (see Figure 7 (d)).

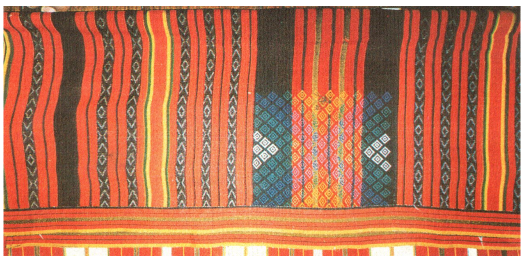
Note that in analyzing the symmetry groups of the patterns, we assume the patterns to be repeating in either vertical or horizontal direction in a particular panel, though they appear of finite length in the resulting *ules* or *tapis*. We also take into consideration the symmetry group disregarding the colors of the patterns; that is we look at the symmetry groups of the uncolored pattern on the fabric. For instance, we disregard the two prominent vertical black hues in middle panel of Figure 5 (b). The same assumptions hold when analyzing the symmetries of the patterns in the other fabrics in this study.

**B. The *Wakes* or *Bakget*.** The *tapis* is usually kept in place with a *wakes* or *bakget*, a piece of cloth about 7.5-10 cm wide, and tightly wound twice around the waist. The Kankana-ey women use the *wakes* for daily wear, while the *bakget* is used for feast or ritual. The *wakes* is worn by the women after giving birth to hold their stomach and pelvic muscles in order to prevent sagging and to make them walk tall and straight.

Strip patterns of *tiktiko* that usually appear in *wakes*, (an example is displayed in Figure 8 (a)) possess a horizontal reflection symmetry. Thus, the symmetry group of such a horizontal strip pattern is of type *p1m1*. On the other hand, each vertical strip pattern on the *bagket* (an example is shown in Figure 8 (b)) usually consisting of *sopo* and zigzag *tiktiko* have vertical and horizontal reflections and has symmetry group *pmm*2. Axes of reflectional symmetries and centers of rotations for these strip pattern examples are given in Figure 9.

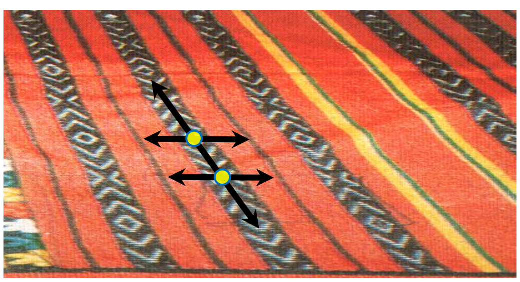

(a)

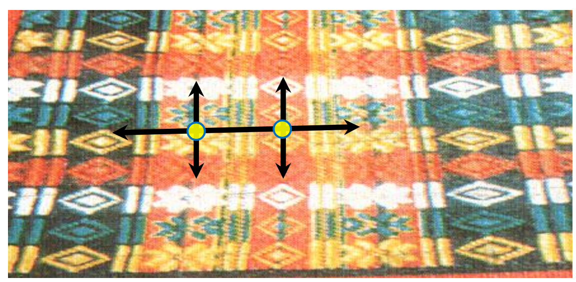

(b)

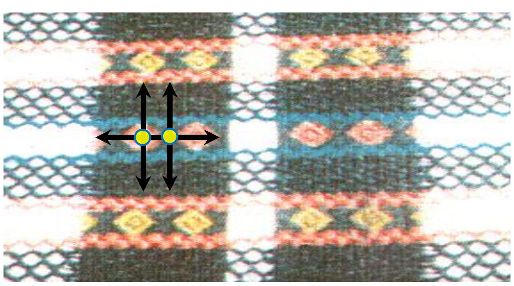

(c)


(d)

**Figure 5**: *Various patterns on an ules or tapis* [6].


(a)


(b)


(c)

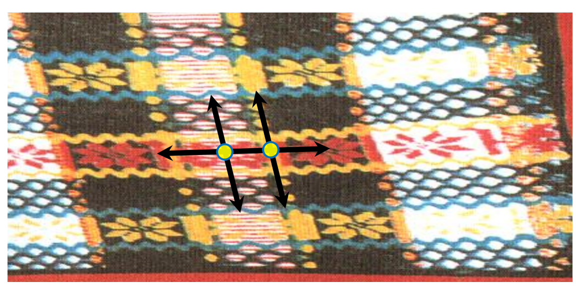

(d)

**Figure 6**: *Axes of reflection and centers of rotational symmetries on the ules/tapis given in Figure 5*.

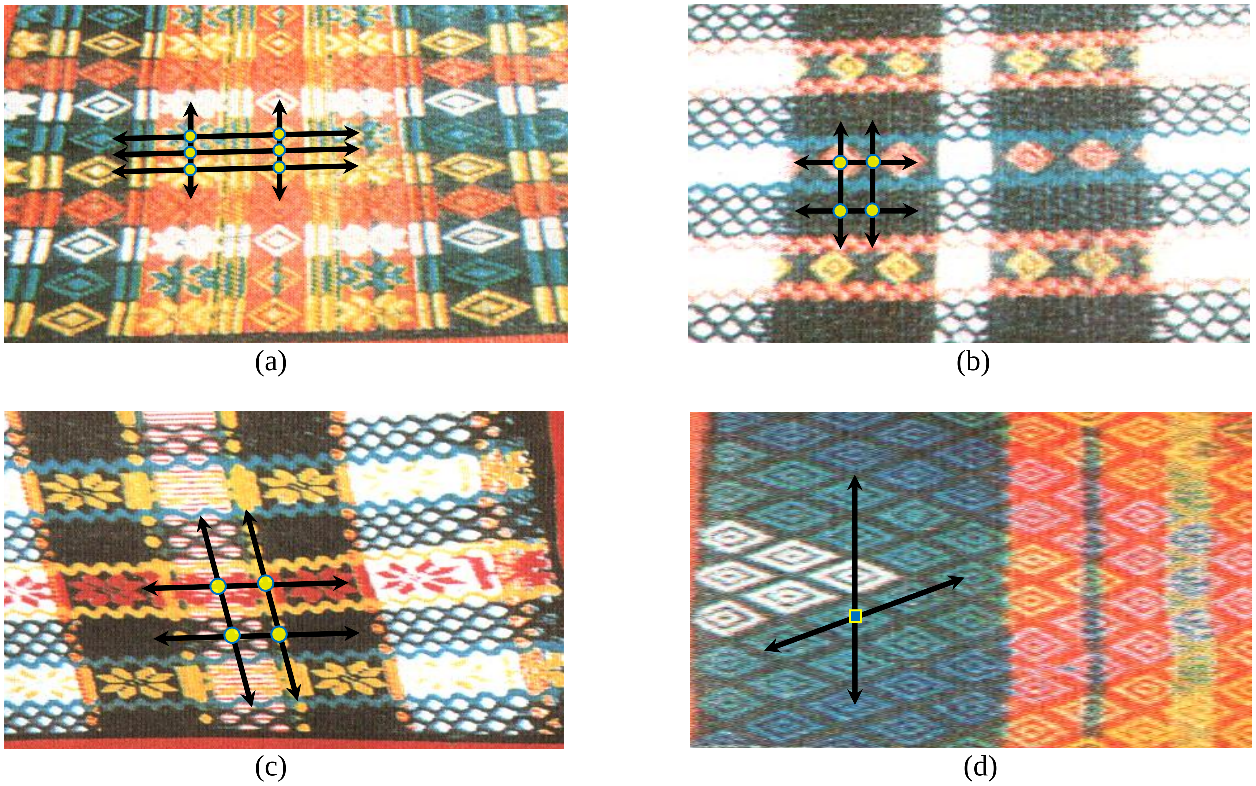



**Figure 7**: *Axes of reflection and centers of rotational symmetries on patterns of Figure 5.*

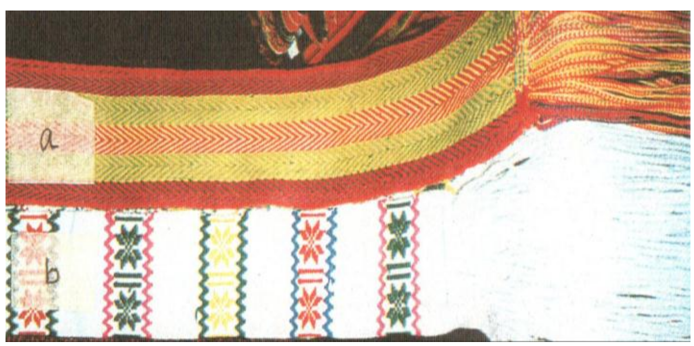



**Figure 8**: *Strip patterns on* (a) *wakes and* (b) *bakget* [6].


**Figure 9**: *Axes of reflection and centers of rotational symmetries on strip patterns of Figure 8.*

**C. The *Wanes*.** The traditional clothing of the Kankana-ey men is the *wanes* or g-string, a piece of woven cloth wrapped around the waist and draped down to cover the loins. This clothing is now worn only during traditional ceremonies and on special occasions. The *wanes* is usually red with colored borders, or sometimes dark blue with red stripes and decorated ends. The decorated ends of the *wanes* (shown in the upper portion of the *wanes* in Figure 10) are usually strip patterns of the combination of zigzag *tiktiko* and *matmata*. Ignoring the vertical strips at the edges of wanes, and treating the strip patterns as extending indefinitely at both ends, we conclude that the symmetry group of these strip patterns is of type *pm11*. These patterns have vertical reflections with axes that are spaced half of the translation length. The axes pass through the centers of the *matmata* and between adjacent *matmata*. At times we find an additional strip pattern running horizontally along the middle portion of a *wanes*, such as that shown in Figure 10 (b). Such a pattern combines a variation of *tiktiko* and *matmata* with a symmetry group of type *pmm2*. The axes of reflections and center of rotations of symmetries of the strip patterns are shown in Figure 11.

(a) (b)

**Figure 10**: *Various patterns on wanes* [6].

(a) (b)

**Figure 11**: *Axes of reflection and centers of rotational symmetries on patterns of Figure 10.*

**Figure 12**: *Patterns on a bedbed*.

(a) (b)

**Figure 13**: *Axes of reflection and centers of rotational symmetries on patterns of bedbed of Figure 12.*

**D. The *Bedbed***. The Kankana-ey men wear a *bedbed*, which is made of either *abel* (cloth) or *kuba* (bark), to cover their short hair and they decorate this with feathers, leaves, and even carabao horns. A typical pattern on the *bedbed* appears in Figure 12. Each vertical strip pattern is a combination of *sopo* and *tiktiko* with symmetry group of type *pmm2*. Combining these strip patterns, a two dimensional pattern is obtained with symmetry group of type *pmm*. Axes of reflection and centers of rotational symmetries are displayed in Figure 13.

## Color Symmetries of the Patterns

In this part of the paper, we give a short discussion on the color symmetries pertaining to the fabrics of the Kankana-ey. Most of the weave patterns we considered in the study are multi-colored; and there are few occurrences of two-colored patterns.

In color symmetry theory, we not only look at the symmetrical pattern, but also the various ways of symmetrically coloring the pattern. Given a colored symmetrical pattern, three groups are usually associated with it [1] : the group $G$ sending the uncolored pattern to itself, the subgroup $H$ of $G$ consisting of elements of $G$ which effect a permutation of the colors, and the subgroup $K$ of $H$ consisting of elements that fix the colors in the given coloring. The groups $H$ and $K$ are called the *color group* and *color fixing group*, respectively associated with the given coloring. If $H = G$, we say the coloring of the given pattern is a *perfect coloring.* Otherwise we say the coloring is *non-perfect* or *not consistently colored.* A characteristic of a perfect coloring is that there is an even distribution of colors in the given colored pattern.

For the fabrics discussed in this note, we assume the patterns to be either a strip pattern or a two dimensional pattern with symmetry group of the uncolored pattern a frieze group or a plane crystallographic group, respectively as discussed in the previous section. We find that all the strip patterns that appear are perfectly colored, where the symmetry group $G$ serves as the color group and color fixing group. A single exception is the strip pattern appearing in the upper portion of the *wanes* shown in Figure 10 (b). This is a non-perfect coloring, where the reflections with axes passing between adjacent *matmatas* interchange the red and yellow colors of the *matmata*; and fix the red and yellow colors of the *tiktiko* (the left most axis in upper part of Figure 11(b) corresponds to such a reflection). Thus, the coloring is non-perfect or not consistently colored.

Treating the designs in the *ules* as two dimensional patterns, we have perfect colorings for the patterns appearing in Figures 5 (a) and (b), and non-perfect colorings for the patterns shown in Figures 5 (c) and (d). For the pattern appearing in the middle panel of Figure 5 (c) there are more green *matmatas* than the white ones. Consequently, there are vertical reflections that fix some of the green *matmatas*, and at the same time interchange green and white *matmatas* (see Figure 7(d)). For the pattern appearing in the middle panel of Figure 5 (d), there is a horizontal reflection that interchanges the red and yellow *sopo* and at the same time interchanges the blue and yellow *tiktiko* (see Figure 7 (c)). Thus the given coloring is not consistently colored.

The two dimensional colored pattern on the *bedbed* is also a perfectly colored pattern.

## Conclusion

The Kankana-ey fabrics have been found to be predominantly longitudinal striped materials, with iconographic motifs so organized as to form a system of well-defined formal relationships. In our analysis of the symmetries and color symmetries of weaving patterns of the Northern Kankana-ey of Mountain Province in the Philippines, we saw that the basic designs or motifs have inherent symmetries. This resulted to the predominance of the existence of horizontal and/or vertical reflections in their weaves. Moreover, the Kankana-ey weavers have organized these basic elements by symmetry motions, thus producing one-dimensional or two-dimensional patterns in their fabric. We wondered how the weavers figured out ways to cross the different threads to make beautiful symmetrical patterns. The principles of symmetry and order seen in the weaving patterns suggest the existence of an underlying mathematical structure about which the Northern Kankana-ey women weavers may be unaware. Thus, we have shown that mathematics is concretely embedded in the people's culture.

The diversity of terrain of the Philippine islands has supported the simultaneous development of widely divergent lifestyles and cultures including the art of weaving. Our on-going study includes analyzing the symmetries and color symmetries of the various patterns that arise in various art forms from the different tribes in the Philippine islands. It would also be interesting to study how the mathematical artworks that arise from these tribes reflect patterns of human behavior and basic values. This would enlarge our knowledge and appreciation of how people have met their basic needs over time and in different culture.

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