Frieze Pattern Analysis of the Aronai Scarf of Assam

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ABSTRACT

Many researchers analyzed algebraic structure in various aspects in culture. Researchers like Mefa Indriati et al, Jay Friedenberg et al, Fevi Rahmawati et al, Ma Louise Antonette et al, Roger D. Capua et al studied Frieze and Crystallographic patterns in some traditional dresses from Indonesia, Phillipines, Netherland, Thailand and USA. Together with analysis of symmetric patterns Yessica Nataliani attempted to code it in MATLAB also. Here our aim is to investigate symmetric patterns in the motifs of Aronai, attire of Bodo which is a significant cultural symbol of Assam promoting rich cultural heritage internationally.

INTRODUCTION

Assam is one state of India. The indigenous Assamese people of Assam are a diverse and culturally rich group with profound historical significance. Assam is home to a variety of ethnic communities, including 29 populations of indigenous tribes, who have assimilated over centuries, and its culture is a blend of traditions from various communities. The indigenous people specially tribes of Assam have distinct traditional attire with unique weaving patterns that reflects their rich cultural heritage and make their attire distinct.

The Bodo is the largest native tribe in Assam, North East India, belonging to the Tibeto-Burman ethno-linguistic group. The Bodo community possesses a distinct culture, language, and individuality: Although they represent a smaller demographic, they are remarkably abundant in all Integral components of community life. As a community their survival is rooted in the nature, so Bodos have developed a culture and economy that mirror the natural world. Hence, the textile traditions of the Bodos also reflect a strong connection to nature through their fabric composition and ornate motifs designs.

Aronai is a traditional hand-woven cloth which is a significant cultural symbol of Assam, it symbolizes respect, purity, and cultural pride which is used in rituals, festivals, and as a gesture of honor in Assam by Bodo community.

Ethnomathematics, the term introduced by Brazilian mathematician Ubi ratan D'Ambrosio in 1977, is the study of the relationship between mathematics and culture and it is today a well-established theory. It explores how different cultural groups develop and use mathematical concepts in their daily lives, traditions and practices knowingly or unknowingly.

How mathematical concepts are embedded in the cultural practices of different communities has been the thrust of Numerous researchers all over the world from different perspectives. In some countries their traditional attires and some cultural components are widely studied for algebraic structures 2 in many directions including their coding. But in India specially in Assam there is no significant study about it. Our attempt in this research is to fill up these gaps.

Gallion stated that an isometry of n-dimensional space R^n is a distance preserving mapping from the space onto itself [6]. Four fundamental types of isometries in $R^2$are rotation, reflection, translation and glide-reflection. The symmetry group of F, is the set of all isometries of R^n that carry F onto itself, where

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composition of functions is the group operation. The symmetry group is one of the concepts that have broad prospect to be studied through culture because it can provide a set of tools to interpret reality with a new aspect, with help of which cultural heritage can be analyzed and classified meticulously. Frieze concept is formed by the repetition of a basic pattern in one direction. The mathematical analysis of these patterns has led to a classification of Frieze group in group theory. It is a subgroup of symmetry groups built by the translation or displacement of a pattern along a straight line with a certain direction and distance. There are two types of infinite symmetry groups, namely discrete Frieze groups and discrete symmetry groups (Wallpaper patterns). The discrete Frieze group are plane symmetry groups of patterns whose subgroup of translation is isomorphic to $\mathbb{Z}$. The other symmetry group has a plane pattern whose translational subgroups are isomorphic to $\mathbb{Z} \oplus \mathbb{Z}$ [6]. Here we will only discuss the discrete Frieze Groups. There are seven types of Friezes. As a part of Ethnomathematics symmetric patterns, especially Frieze patterns of traditional dresses, different areas of different countries have drawn attention of many researchers.

Mefa Indriati, Turmudi, Jar nawi Afgani Dahlan. studied Frieze Pattern on Siak Weaving Motifs [7]. Yessica Nataliani analysed Frieze Group in Generating Traditional Cloth Motifs of the East Nusa Tenggara Province [9]. Jay Friedenberg, Preston Martin, Naomi Uy, Mackenzie Kvapil observed the aesthetics of Frieze patterns as effects of symmetry, motif, and element size [5]. Fevi Rahmawati Suwanto, Dinda Kartika and Debi Yandra Niskac, Chin A.Y.M, analyzed Frieze and Crystallographic Patterns on Ulos [10]. Ma. Louise Antonette N. De las Pe˜nas, Agnes D. Gar ciano and Debbie Marie Verzosa discussed Color Symmetry in the Hand-Woven Mats of the Jama Mapun[4]. Roger D. Capua, Joseph B. Tandas, Jairuz D. Bissoyo investigated Frieze Pattern of the Eastern Cordillera three Major Ethnic Groups Woven Native Attire [3]. Ron Eglash, discussed symmetry in Ethnomathematics. Shailesh A ShiraZi examined symmetry specially Frieze Groups in the World of Man and Nature, Liyana A. Truna, Noria B. Tugang, Norhunaini C. Mohd Shaipullah and Nur Rasfina D. Mahyan studied Frieze patterns in Pua Kumbu from Sarawak [11].

The objective of this paper is to explore, preserve, popularize, and analyze the motifs of widely used Aronai from the mathematical perspective, especially geometry elements in the motifs of these attires using Frieze groups.

Frieze Group

Frieze Groups are the infinite symmetry group in two dimensions, where the group of translation is isomorphic to Z. It is a combination of four isometries, translation, rotation, reflection and glide reflection that preserve the distance, shape and size of the motif or pattern.

- **Translation**: If one pattern or motif moves in one direction from one point to another preserving the distance then it is considered as translation.

$$m \quad m \quad m \quad m \quad m \quad m \quad m \quad m \quad m \quad \cdots$$

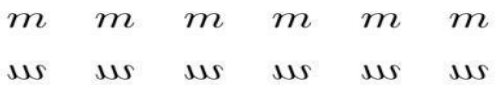
- **Rotation**: If one pattern is turned about a fixed point and 180° angle then preserving the distance it is considered as rotation.

$$\begin{array}{cccccccccc} m & m & m & m & m & m & m & m & m & m\cdots \\ \hline u & u & u & u & u & u & u & u & u & u^{\cdots} \end{array}$$

- **Reflection**: A pattern exhibits reflection if it produces mirror images across a vertical and horizontal line.

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Vertical Reflection



Horizontal Reflection

- **Glide reflection:** If a pattern is reflected across a line and then translated along then it is considered as glide reflection.



Glide Reflection

A frieze pattern is generated by combining translation with other symmetry operations, namely vertical reflection, horizontal reflection and Glide reflection. Based on the symmetries present, frieze patterns are classified into seven distinct types of frieze groups. The seven frieze groups are named using the notation introduced by the International Union of Crystallography (IUCr). The code consists of four symbols: p denotes translation, m denotes vertical reflection and horizontal reflection, a denotes glide reflection,1 denotes if no other symmetry is present and 2 denotes 180° rotation. the seven frieze groups denoted using these codes as follows are p111, p1a1, pm11, p112, pma2, p1m1 and pmm2. In addition to the crystallographic notation, frieze groups are also denoted using the symbols F_1, F_2, F_3, F_4, F_5, F_6, F_7 as presented by Joseph A. Gallian [6].

In the following section, we discuss the seven frieze groups individually, describing their respective symmetric operations, algebraic structures and corresponding patterns to provide a systematic classification of frieze groups.

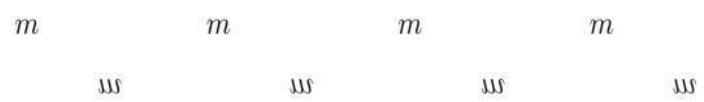
1. **For p111/F_1**

Here the translating unit is

It is a first frieze pattern with translation only and is isomorphic to $\mathbb{Z}$.

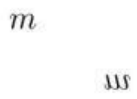
$F_1 = < t > \cong \mathbb{Z}$

2. **For p1a1/F_2**



ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

Here the translating unit



The Second frieze group is generated by translation t and glide reflection g, is isomorphic to $\mathbb{Z}$

$F_2 = \langle g \mid t = g^2 \rangle \cong \mathbb{Z}$

3. For pm11/F_3



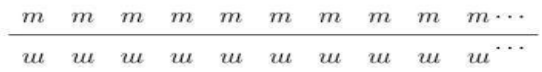
Here the translating unit is



The third frieze group is generated by combination of translation t and vertical reflection v, and is isomorphic to D_∞.

$F_3 = \langle t, v \mid v^2 = e, vtv^{-1} = t^{-1} \rangle \cong D_\infty$

4. For p112/F_4



Here the translating unit is



The fourth frieze group is generated by combination of translation t and 180° rotation r, is isomorphic to D_∞.

$F_4 = \langle t, r \mid r^2 = e, rtr^{-1} = t^{-1} \rangle \cong D_\infty$

5. For pma2/F_5



Here the translating unit is

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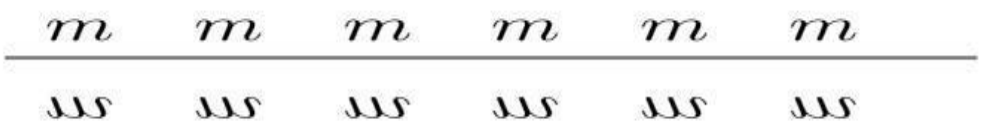


The fifth frieze group is generated by combination of glide reflection g and vertical reflection v, and is isomorphic to D∞.

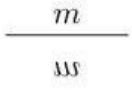
$F_5 = \langle g, v \mid v^2 = e, vgv^{-1} = g^{-1} \rangle \cong D_\infty$

and $g^2 = t$ where t is translation.

6. **For p1m1/F_6**



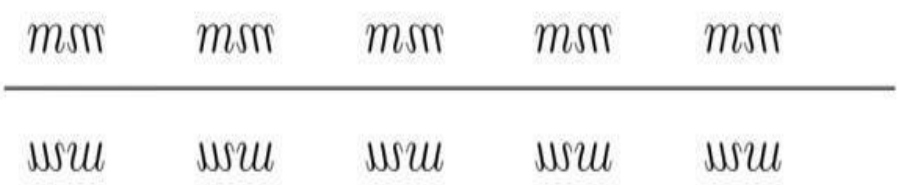
Here the translation unit is



The sixth frieze group is generated by combination of translation t and horizontal reflection v, is isomorphic to $\mathbb{Z} \oplus \mathbb{Z}_2$ where $\mathbb{Z}$ represents translation and $\mathbb{Z}_2$ represents the group generated by horizontal reflection.

$F_6 = \langle t, h \mid h^2 = e, th = ht \rangle \cong \mathbb{Z} \oplus \mathbb{Z}_2$

7. **For pmm2/F_7**



Here the translating unit is



The seventh frieze group is generated by combination of translation t, horizontal reflection h, vertical reflection v, is isomorphic to $D_\infty \oplus \mathbb{Z}_2$ where D_∞ represent the group generated by translation and vertical reflection and $\mathbb{Z}_2$ represents horizontal reflection.

$F_7 = \langle t, v, h \mid v^2 = e, h^2 = e, vtv^{-1}=t^{-1}, th = ht, vh = hv \rangle \cong D_\infty \oplus \mathbb{Z}_2$

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

METHODOLOGY

The research is a descriptive method, by collecting data in the form of images and their information related to motifs of Aronai Scarf through literature, observations and interviews with Bodo weavers and women, mainly in the Kokrajhar region of Bodoland, Assam. All the images were also collected from the participants whichever were present with them. And then identification of motifs was carried out to investigate the research objectives which is mainly geometrical exploration and study of algebraic structures in Aronai Scarf of Bodo community. Also, the names of the different motifs are orally provided by the interviewees and collected from other journals, research papers.

For the present study, the collected images were examined first to identify repetitive motifs present in the scarves and further classified into Frieze group structures. The unit of analysis was specified for each example as either an individual motif, a band containing repetitive motifs of the Aronai Scarf. Also, in identifying the Frieze group structures, analysis primarily depends on the geometric shapes of the motifs irrespective of the colour in which they appear and irrespective of its combination with other motifs in the original shape.

RESULT AND DISCUSSION

Bodo people use their own traditional designs and motifs into their traditional clothes. In Bodo, Agor means motif or design. The designs or motifs found in traditional Bodo cloths and Aronai are largely inspired by nature. These motifs reflect the rich natural surroundings and cultural heritage of Bodo community.

These motifs may be broadly categorized into four different groups as follows.

- Animals: The motifs inspired by animals including birds, butterflies, tigers, etc. Some of these motifs are known as Phareo Megon (pigeon eyes), Dautho gwdwna agor (neck of dove), Khaseo Bikha (turtle heart) etc.

- Floral: The motifs inspired from leaves and flowers are known as Singri bibar (singri flower), Bwigri bibar (flower of plum) etc.

- Natural objects: The name of some motifs inspired from natural objects used in bodo textile are Hajw Agor(hill), Dingkhia Agor (fern of dhekia) etc.

- Man made objects: Motifs adopted from man-made objects are necklace, nose stud, etc

But nowadays it is observed that many weavers are making slight modifications into their traditional motifs while preserving their cultural heritage. Although the Bodo community incorporates many more motifs into their traditional textiles, including dokhona and other traditional garments, the present study focuses exclusively on the motifs used in Aronai.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026



Image 1:Some images of Aronai with Bonduram Agor



Image 2: Some images Aronai with different motifs

This section presents details discuss of the motifs used in Aronai including their names and meaning. Furthermore, each design is classified according to corresponding frieze groups based on symmetries of particular motifs irrespective of its colour and combination with other motifs.

Hajw Agor: The word hajw means hill and Agor means motif. It is inspired from the hills in nature. It is one of the most used motifs in Aronai. Almost in every Aronai we see hajw agor. This agor is used in the border of aronai.

Dingkhia Agor: A design represents fern of dhekia. It is also used on the border of Aronai.

Although the meaning of these two motifs is different, sometimes, they are regarded as the same due to their shape. Hajw agor is slightly narrower and the Dingkhia agor is comparatively broader in shape.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

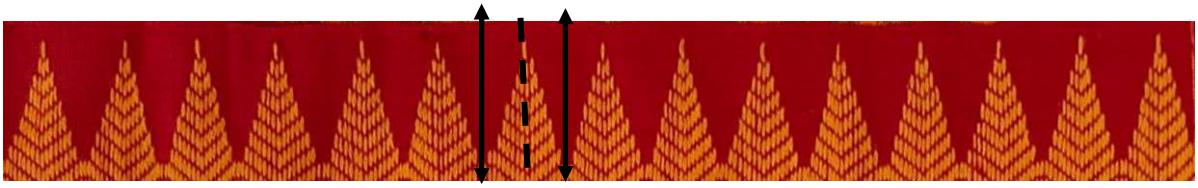


Image 3: Hajw Agor with pm11 pattern

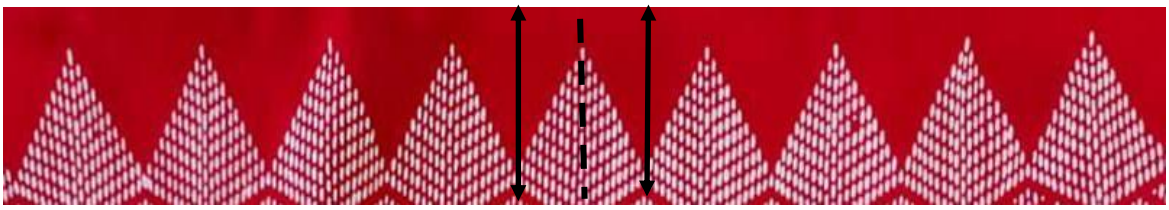


Image 4:Dingkhia Agor with pm11 pattern

Both the motifs are repeated in one direction and they are also vertically reflected. The motif between the two black arrows translated throughout while the dotted line indicates the axis of reflection. Hence the motif is classified as the frieze group pm11

Bonduram Agor: The term bondu means friend, and Bonduram Agor represents friendship between people. This is the most used and common motif in Aronai.

Both the design shown in Image 5 are identical, however slight visual differences are appearing because of the weaving process and the types of threads used in weaving.



Image 5:Bonduram Agor with pmm2 pattern

Here the pattern exhibits translation, vertical reflection and horizontal reflection. The motif between the two black arrows translated throughout, while the dotted line indicates the axis of reflection both horizontal and vertical. Therefore, the motif is classified as the frieze group pmm2.

Phareo Megon: It means pigeon eyes. This motif is inspired from the Bird pigeon. The motif is characterized by a diamond shape. Also, it is a slightly modified version of the original one.

In the image the primary diamond shaped motif (Phareo Megon) is accompanied by some additional motifs. However, if this secondary motif is neglected and only the core diamond shaped motif is considered then it categorizes as pmm2 frieze pattern.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

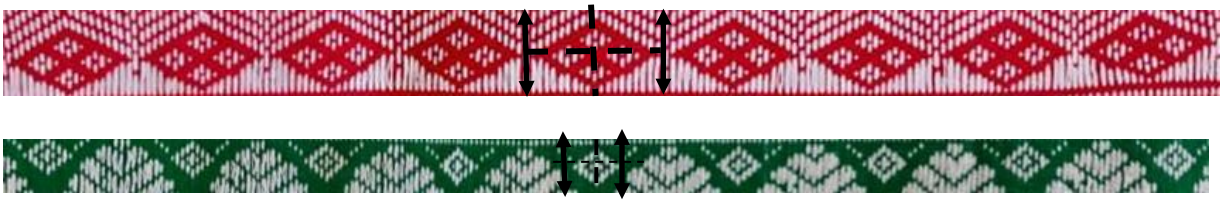


Image 6: Phareo Megon with pmm2 pattern

The motif between the two black arrows translated throughout, while the dotted line indicates the axis of reflection both horizontal and vertical. As it consists of translation, vertical reflection and horizontal reflection.

Singri Bibar: It means singri flower (common wood sorrel).

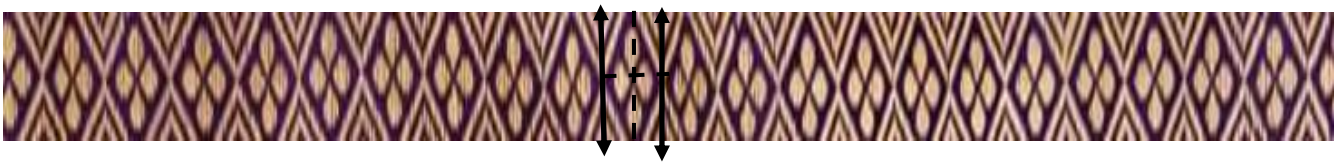


Image 7:Singri bibar with pmm2 pattern

Bwigri bibar: It is a motif that represents a flower of plum.

Here also the images of Singri bibar and Bwigri bibar are accompanied by some other motifs. The flowers between the diamond shape are Singri Bibar (Image 7) and Bwigri bibar (Image 8).

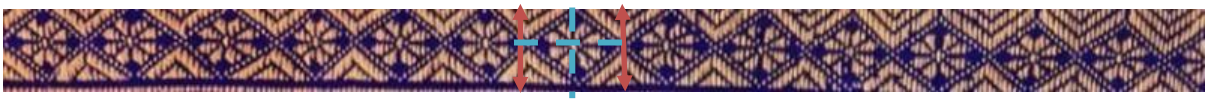


Image 8: Bwigri bibar with pmm2 pattern

The motif between the two arrows translated throughout, while the dotted line indicates the axis of reflection both horizontal and vertical. It also consists of translation, vertical reflection and horizontal reflection so it is categorized as a pmm2 pattern.

Agor Gubwi: It represents the main design.

Here the motif is repeated in one direction and also horizontally reflected. Hence the motif is classified as a p1m1 pattern which consists of translation and horizontal reflection.



Image 9:Agor Gubwi with p1m1 pattern

The motif between the two arrows translated throughout, while the dotted line indicates the axis of reflection.

Lau Begor: It represents the seed of bottle gourd. This motif is slightly oval in shape.

Here also the main motif is accompanied by some other motifs, if the other motif is ignored the pattern exhibit both translation and vertical reflection which makes it frieze pattern pmm2.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

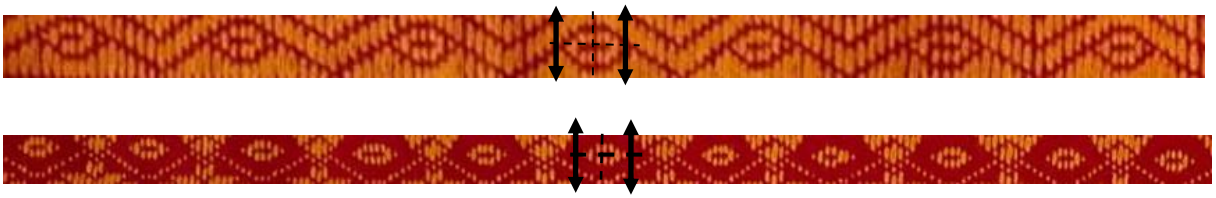


Image 10:Lao Begor with pmm2 pattern

The motif between the two black arrows represents translation throughout, while the dotted line indicates the axis of reflection.

Laosong Agor: It represents a motif or flower which is long but beautiful.

Here we can see that it is a pattern consisting of translation, vertical reflection and horizontal reflection. Hence it is classified as a pmm2 pattern.

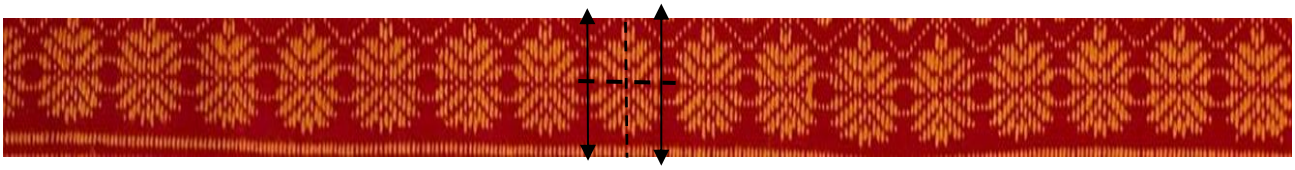


Image 11:Laosong Agor with pmm2 pattern

The motif between the two black arrows translated throughout, while the dotted line indicates the axis of reflection both horizontal and vertical.

Jinjiri Agor: It represents a motif which looks like a chain pattern.

Here we can only find that the pattern is repeated in one direction and no other symmetry is there.

Hence, it is a p111 pattern with translation symmetry.

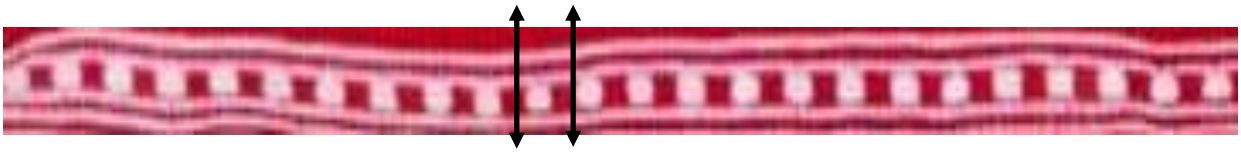


Image 12:Jinjiri Agor with p111 pattern

The motif between the two black arrows represents the repeating unit of the Frieze pattern.

Dautho Gwodwna Agor: It represents the neck of a dove.

Here the main motif is accompanied by some additional motifs, resulting in frieze pattern pm11 that exhibit translation and vertical reflection only. However, when the accompanying motif is neglected, the resulting pattern exhibits translation, vertical reflection and horizontal reflection symmetry which makes it a pmm2 pattern.

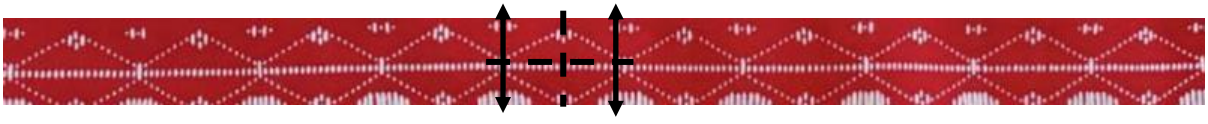


Image 13:Dautho Gwodwana Agor with pmm2 pattern

The motif between the two black arrows is translated throughout, white the dotted line indicates the axis of

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue X, October 2026

reflection both horizontal and vertical.

Khaseo Bikha: It represents the heart of a turtle. It is also slightly modified.

Here the motif repeats in one direction and it is also both vertically and horizontally reflected. Hence, it is classified as pmm2 pattern.

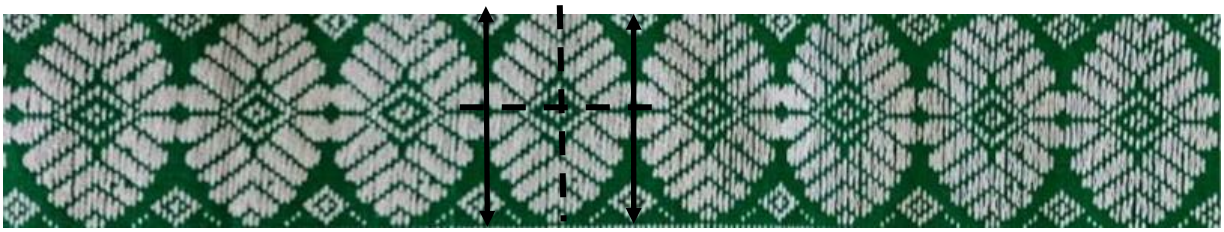


Image 14:Khaseo Bikha with pmm2 pattern

The motif between the two black arrows translated throughout, while the dotted line indicates the axis of reflection both horizontal and vertical.

Based on all the observations, the motifs in the Aronai exhibit 4 types of frieze patterns that are p111, pm11, p1m1 and pmm2. Among all the four patterns the 7th frieze pattern pmm2 is mostly found in almost all the motifs with other patterns appearing less frequently.

CONCLUSION

This research paper is dedicated to study the Frieze groups structures of the motifs present in Aronai, reflecting use of deep concepts of Mathematics just in a part of rich hand-woven culture of Bodo women of Assam. Investigations revealed only 2 types of Aronai, one with Bonduram Agor and another with floral Agor, however variations in colour may occur as different weavers may use different colours for the same types of motifs. The study identifies 4 types of frieze patterns that are p111, pm11, p1m1 and pmm2 in these motifs (agors) out of which 7th frieze pattern pmm2 is largely observed.

It has a visionary future prospect to investigate algebraic structures in depth and generate its computational structures that can be studied in many directions.

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