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Natural dyes used by the byak tribe and its prospects as raw materials for the natural dyes industry

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Abstract. Dyes have been widely used by communities for various purposes, such as a compositional ingredient in food, customs, or traditional activities and crafts. The types and methods of usage are highly dependent on the presence of plants and animals found around residential areas and there are also several exotic species that are assimilated and come from other ethnic groups. The aim of this study is to determine the types of plants that produce natural dyes used by the Byak community in Biak Numfor Regency as handicraft dyes and the prospects for cultivating these plants as a source of raw materials for the natural dye industry. The research showed that the Byak ethnic community used eight species of plants as dye materials for handicraft products such as *Asytasia gangetica* (L.), *Melastoma maladatthricum* (L.), *Arcangelisia flava* (L) Merr, *Morinda citrifolia* (L), *Philantus* sp., *Macaranga tessellate* var *glabrescens*, *Mallotus floribundus* (Blume) Mull.Arg., and *Bruguiera gymnorhiza* (L) Lank. From all the species *Asytasia* sp. is easier to cultivate using stem cuttings and is relatively fast-growing.

1. Introduction

Indonesia is a country with the second largest tropical forest in the world and has a high diversity of plants so it is known as one of the 7 (seven) "mega bio-diversity" countries. This wealth also includes herbs that can produce dyestuffs. Besides plants and animals, Indonesia is also rich in ethnic and cultural diversity, with a total of 1,068.

Natural dye plants in Indonesia have recorded approximately 150 species and have been used for industrial purposes of wood, bamboo, pandanus, and batik handicrafts (cotton, silk, wool) with several color compositions such as yellow, blue, orange, and red (Mansour R, 2018) [3].

The lives of indigenous Indonesians who cannot be separated from the forest are seen in various life-support objects for daily interests such as foodstuffs, medicine, building materials, traditional ceremonies, culture, and coloring materials. Indigenous Papuans are also familiar with natural coloring agents that can be used in food (Sutarno S, 2001) [14], and used to color carving materials and color traditional clothes and bags (Ryan I, 2019) [11].

There are eight types of non-timber forest products that are used as a source of natural dyes for the Papuan people, whose use is spread in several areas, namely Biak, Yapen, Arfak, and Sorong. The name of the species is *Arcangelesia* sp, *Callophyllum inophyllum*, *Leea zippetiana*, *Morinda cutrifolia*, *Nauclea* sp, *Prema corymbosa*, *Pterocarpus indicus*, and *Rhizophora macronata*.



Generally natural dyes have an important value in the lives of traditional people who are far from modern life like most regions in Papua (Pullaiah T *et al.*, 2011)[7]. Although in some indigenous people, this custom began to change with the use of synthetic dyes. Synthetic dyes have several advantages compared to natural dyes, namely, among others, they are easy to obtain in the market, guaranteed color availability, have diverse color types, and are more practical and easier to use [6,12].

The Byak tribe or what is now called the Biak tribe is one of the tribes of 261 ethnic groups in the Land of Papua (Ananta *et al.*, 2016) [1]. This tribe is a native of Biak Numfor Regency, Papua Province which inhabits lowland and coastal ecological zones, and in the Cenderawasih Bay area is one of the tribes in the saireri cultural zone. The nature of openness and friendliness with other people who are not Biak people has become their habit of life for a long time, even though they are known among the ethnic groups in Papua as hard-tempered people.

The Byak tribe also has natural dyes but has not scientifically documented the types of natural dye plants used by this tribal community. This is the basis for conducting research on the use of natural colors in the life of the Byak tribe. The purpose of this research is to find out the species of natural dyes used by the Byak tribe, the methods or processes carried out in producing natural dyes and how to apply them to traditional objects.

2. Methods

2.1. Location

This research was conducted in Wouna Village, Andey District and Rimba Jaya Village, East Biak District, Biak Numfor Regency, Papua, with a study time of ± 4 weeks (May - June 2021). The determination of the location of the study was carried out deliberately by seeing that the people of both locations still use natural dyes

2.2. Method of the study

The method used in this study is a descriptive method with semi-structural interview techniques that refer to questionnaires and field observations to document plant species and record species names using tally sheets. Respondents were appointed intentionally or purposefully, which included people who had knowledge of natural dye plants for generations. The results obtained are processed and displayed in the form of tabulations and drawings. The variables that have been identified are the species and families of plants that are used as natural dyes, the part of plants that are used, and the traditional process of plant extraction.

2.2.1. Stages of research implementation

1. The stages of research are as follows:
2. Observation; is a data collection activity carried out by direct observation in the field, so that it can describe factually, carefully, and in detail the traditional dyes in all aspect
3. Interview; is a data collection activity carried out by asking questions to respondents based on a questionnaire but carried out like a normal chat (semi-structural interview)
4. Documentation studies; is a data collection activity carried out to obtain written data through documents/books, pictures, photos, or the like to support data obtained through observation and questionnaires.
5. Data Analysis: Data obtained using tables, and images obtained.

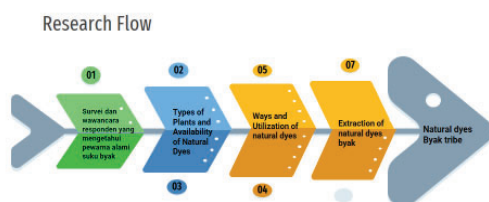


Figure 1. Research Flow

3. Results and discussion

3.1. Dyes Species and the color

The results of the study showed that the plants used as natural dyes of the Byak Tribe are 8 (eight) species in 7 (seven) families. Natural dyes known by the Byak people are only used to dye wood fibers as raw materials for traditional bags (Inoknson), coloring tifa, used in paintings, boats and in carvings of sculptures, crossbows and spoon to make sagu food. The list of plant species that are used as natural dye plants along with the parts used and the resulting colors is presented in Table 1.

Tabel 1. The Species of plants that used as natural dyes and parts used.

No	Local Name	Species	Family	Parts Used	Color
1	Ruja	<i>Asytasia gangetica</i> (L)	Acanthaceae	Leaves	Red
2	Pim	<i>Melastoma maladatthricum</i> (L)	Melastomaceae	Fruits	Darky Blue
3	Inggamines	<i>Arcangelisia flava</i> (L) Merr	Menispermaceae	Stem	Yellow
4	Kandarek	<i>Morinda citrifolia</i> (L)	Rubiaceae	Root	Yellow
5	Sewu	<i>Philantus</i> sp	Phylanthaceae	Bark	Red
6	Sapiyai	<i>Macaranga tessellate</i> var. <i>glabrescens</i>	Euphorbiaceae	Tree sap	Red
7	Barnesem	<i>Mallotus floriBbundus</i> (Blume) Mull.Arg	Euphorbiaceae	Tree sap	Brown
8	Aibon	<i>Bruguiera gymnorrhiza</i> (L) Lamk	Rhizophoraceae	Bark	Brown

The families of the dyes are Acanthaceae, Melastomaceae, Menispermaceae, Rubiaceae, Phylanthaceae, Euphorbiaceae, and Rhizophoraceae. Euphorbiaceae have two species, *Macaranga tessellate* var. *glabrescens* and *Mollotus floribundus* (Blume) Mull. Arg, and the other families have only one species (Tabel 1).

When compared to natural dye research in Papua, these two species here are not yet commonly used because the species of plant that is commonly used by people in Papua is the *Morinda citrifolia* [2,7].

3.2. Colors produced and their uses

Red is primarily produced by natural dye plants of the Byak tribe, such as *Asytasia gangetica* (L), *Phyllathus* sp, and *Macaranga tessellate* var. *glabrescens*. *Philantus* sp and *Bruguiera gymnorrhiza*. The species of dye plants in this tribe produce red, blue-black, brown, red, and yellow. The color is used for coloring bags, tifas, crossbows, boats, carvings, and other tools. Dye plants, colors produced, and their uses are shown in Table 2.

Tabel 2. The Use of Dye Plants in People's Lives Byak Tribe in Village Rimba Jaya and Village Wouna.

No.	Species	Local Name	The resulting color	Utility
1	<i>Asytasia gangetica</i> (L)	Ruja	Red	Coloring fiber woody bags name inokson
2	<i>Melastoma maladatthricum</i> (L)	Pim	Darky Blue	Coloring inokson and tifa
3	<i>Arcangelisia flava</i> (L) Merr	Inggamines	Yellow	Coloring traditional boat and the wall of house
4	<i>Morinda citrifolia</i> (L)	Kandarek	Yellow	Coloring traditional boat and for painting
5	<i>Philantus</i> sp	Sewu	Red	Coloring traditional boat and the wall of house
6	<i>Macaranga tessellate</i> var.glabrescens	Sapiyai	Red	Coloring traditional boat and tifa
7	<i>Mallotus floriBbundus</i> (Blume) Mull.Arg	Barnesem	Brown	Coloring traditional boat and tifa
8	<i>Bruguiera gymnorhiza</i> (L) Lamk	Aibon	Brown	Coloring traditional boat and painting

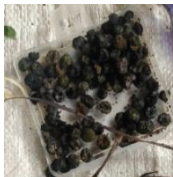
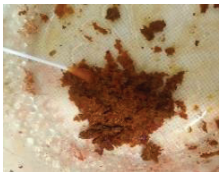
Table 2 shows that coloring in the traditional Byak tribe particularly dyes bark and wood fibers for their traditional tools and instruments like coloring traditional boats and tifa also for coloring paint. The coloring activities using eight (8) species is important for them, that is why the knowledge have given from generation to generation.

3.3. The process to produce natural dye and the resources in plants organs

The process of natural dye and the resources from plant organs have been shown in Table 3.

Table 3. The process of natural dye, the product, and utilization.

Species	Organ of Plants	Material	Additional Material	The Color Product	The Process
<i>Asytasia gangetica</i> (L) (Ruja)	Leaves 	Fresh	-	Red 	Boiling the leaves until the red color appears then put wood fiber that need coloring processing for 30 minutes or more according to the strong color that we need

<i>Melastoma maladatthricum</i> (L) (Pim)	Fruits 	Mature	-	Blackish Blue 	The mature fruits mash to smooth, mixed with some water until the blackish blue color appears then put the wood fibers namely warmares or madwes until all parts become blackish blue and next dry under the sun shining for 1 to 2 hours.
<i>Arcangelisia flava</i> (L) Merr (Inggamines)	Stem 	Fresh	-	Yellow 	Cleaning the stem by scraping the bark and hitting the wood then putting the chalk coral or chalk shells and the yellow color appears. it can be used for other purposes
<i>Morinda citrifolia</i> (L) (Kandarek)	Roots 	Fresh	-	Yellow 	Roots are cut and cleaned by scraping the bark and then putting some coconut oil let them for 15 to 20 minutes and the yellow color appears
			Chalk shells	Red 	Roots are cut and cleaned by scraping the bark and then mixed with chalk shells until the red color appears
			Charcoal	Black 	Roots are cut, cleaned, and mixed with charcoal until a black color appears
<i>Philantus sp</i> (Sewu)	Bark 	Fresh	-	Red 	Bark ground until smooth or easy to knead and the red color appears

<i>Macaranga tessellate</i> var. <i>glabrescens</i> (Sapiyai)	Sap wood 	Fresh	Chalk shells	Red 	Sap wood mixed to chalk shells for 1 to 2 hours or a long night until the red color appears. For strong color need more hours
<i>Mallotus floribundus</i> (Blume) Mull. Arg (Barnasem)	Sap wood 	Fresh	-	Brown for 	After cutting the branching the brown sap wood is present. Get some and put to fiber wood until all fibers become brown
<i>Bruguiera gymnorhiza</i> (L) Lamk (Aibon)	Bark 	Fresh	-	Red 	Bark are gotten and clean it. Then blender bark after put some water. For minutes the red color appeared. The color is ready to use for example for painting bark wood or coloring the traditional Byak music instrument namely tifa. Sometimes the water additional is hot water for producing the strong red color

According to Table 3, it is known that the natural dye plant parts used include all parts namely roots, leaves, fruits, bark, and sap. Natural dyes in plants are distributed in almost all plant tissues ranging from flowers, fruits, leaves, wood, roots and rhizomes. The root part used is *Morinda citrifolia* (L) root. This plant not only produces a dark yellow color but can also produce a red color. Roots without mixing will produce a dark yellow color but if mixed with chalk shells will produce a red color.

The use of bark is carried out on plants from the Euporbiaceae family, namely *Mallotus floribundus* (Blume) Mull. Arg and *Macaranga tessellate* var. *glabrescens* are directly taken from the stem sap and are scraped first on the inner bark. The use of part of the bark of the trunk is also found in the plant *Bruguiera gymnorhiza* (L) Lamk is used to produce a red color.

Meanwhile, for the stem section, *Arcangelisia flava* (L) Merr is used to produce a yellow color. In addition to the Byak people, the Arfak people actually also use this type of plant commonly known as yellow wood to produce a bright yellow color. This yellow rope can also be used as a malaria drug (Anom Indra, 2022).

The use of leaves is found in *Asytasia gangetica* (L) to produce a red color. Meanwhile, dyes derived from the fruit are found in *Melastoma malathricum* (L) which produces a blackish blue color. These last two species namely *Asytasia gangetica* (L) commonly called ruja and *Melastoma malathricum* (L) commonly called pim are species of dye plants that are still and are often used today by the Byak people. The coloring process for the two species of plants that are most often used by the Biyak tribe is presented in Figures 1 and 2 as follows.

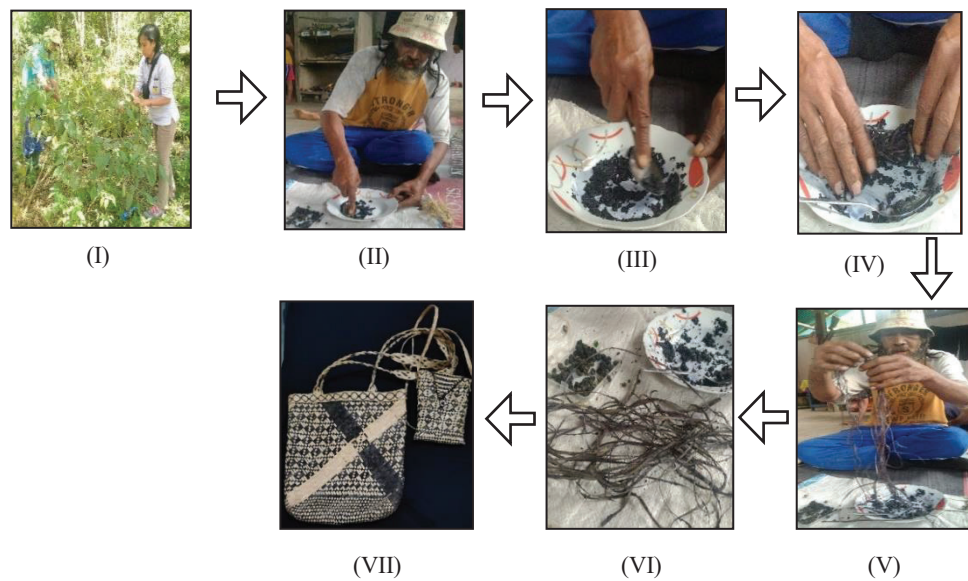


Figure 2. The Process of natural dye using Pim *Melastoma malathricum* (L)

(I) Pim ; (II) Get the fresh mature fruits; (III) Put water in pim and grind to crumbles (IV) the blackish blue color appear (V, VI) then put the wood fibers namely warmares or madwes until all parts become blackish blue and next drying under the sun shining for 1 to 2 hours (VII) application of pim to traditional bag.

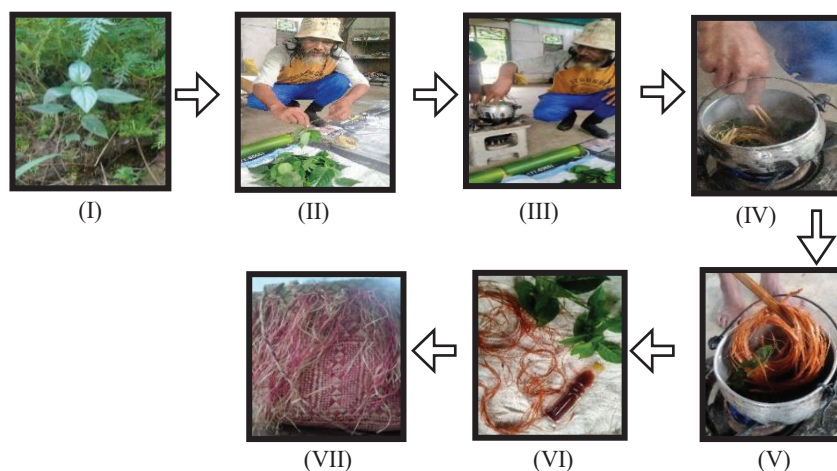


Figure 3. The Process of natural dye using Ruja: *Asytasia gangetica* (L))

(I) Ruja ; (II) Get the fresh leaves; (III) Put water in ruja leaves then boil it (IV) Boiling the ruja color with woody fibers; (V) for 30 minutes ; (VI) wood fibers after boiling ; (VII) application of Ruja in inoknson red bag.

3.4. Prospects as raw materials for the natural dyes industry

Natural dyes by the Byak people in Biak Numfor Regency from Ruja, Pim, Inggamines, Kandarek, Sapiyai, Barnesem, Sewu, Aibon plants are used to dye bark fibers for making traditional Inoknson bags, coloring painting parts, dyeing tifa bodies, house walls, gete-gete papeda, and boats. The availability of color-making materials in Kampung Wouna and Kampung Rimba Jaya is still available and available in sufficient quantities. Generally, no cultivation or propagation of species has been carried out in natural dye plants except ruja.

Pim and ruja plants have been propagated around the house by some families albeit in limited quantities. In contrast to others, some plants, namely kandarek, barnesem and sapiyai are natural dye plants that are easy to grow, especially in former garden areas and because they are not often used, there has been no cultivation effort. For sewu plants, it is rarely found but there is no cultivation yet, this is different from the aibon dye plant that has been propagated, but it is classified as a dye that is not routinely used.

Extraction with water solvents produces red, blue-black, yellow, and brown colors. The color that is widely produced is red with color stability that is visible through the boiling process or used directly or with fresh extract. It is suspected that water solvents that are in neutral PH help the appearance of a sharp red color. A sharp and bright red color is obtained at neutral pH conditions (pH 6-7).

This color will shift towards purplish red with increasing pH. On the contrary, at a low pH (pH 2-5) a yellow color will form. There are several factors that affect the stability of the brazilein pigment. Mordan serves as a means of attachment for color absorption (Sarkar, 1995) and as a chemical bridge between dye molecules and dyed tissue molecules, thus making color permanent.

The color results of the ruja and pim plants that have been applied through the coloring of bark fibers used in traditional inoknson bag products have good color resistance from the time they are stained to become products. Natural dye plants are taken and adjusted in quantity to the bark fibers to be dyed and then staining the product on the spot if desired for a stronger color this process will be repeated in a few days.

Thus, the resulting color will be durable and striking. For example, a bright and dense red color is desired, so more dye plants are needed with less amount of bark fibers and boiling of ruja leaves and bark for up to 2 (two) days, the color will still look red and the more resistant the color produced. The application of color to some traditional products of the Byak tribal people is presented in Figures 3,4 and 5.



Figure 4. Pim Fruits
(A₁: Pim, produce blackish blue, woody fibers with blackish blue color); (A₂: Application in inoknson bags)



Figure 5. Ruja leaf
(B₁: Ruja Leaves, produce red color, woody fibers using red color); (B₂: application in red Inoknson bag)

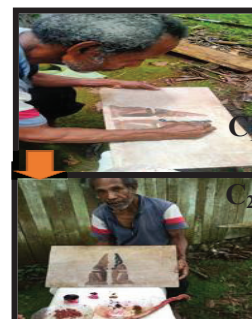


Figure 6. Kandarek fruits
(C₁: Kandarek fruits, produce yellow, black and red color); (C₂: application in traditional painting)

The colors produced in Figures 4, 5 and 6 above have the potential to be applied to other materials and encourage the development of this coloring agent as a natural source of dyes for industry, especially for the two species that are always used, namely ruja and pim.

3.5. Taxonomy and description of the two most used plant types

A. *Asytasia gangetica* (L) /Ruja

Clasification of Ruja

Kingdom : Plantae
 Divisi : Magnoliophyta/Spermatophyta
 Kelas : magnoliopsida/Dicotyledoneae
 Ordo : Scrophulariales
 Famili : Acanthaceae
 Genus : Asytasia
 Spesies : *Asytasia gangetica* (L)



Figure 7. Ruja and the Flower

3.5.1. Description of *Asytasia gangetica* L. (Ruja)

This herbaceous plant has an average height of about 20-40 cm which is found in Wouna Village, Andey District and in Kampung Rimba Jaya Biak Timur (Figure 7). **Roots:** taproot, small branched and there are root hairs, the roots are brownish-white. **Stem:** soft-stemmed, elongated square shape, brownish-green in color. **Leaves:** the position of the leaves facing each other, elliptical in shape, rounded base, pointed tip, pinnate, stemmed and green leaf bones. **Flowers:** compound, densely arranged in grain-like bunches, the corolla is white and purplish in color, the petals cover the ovary. **Fruit:** box pod shape, 2-3 cm long and 0.5 cm wide, in one pod there are seeds numbering approximately 4 seeds, ripe brown. **Seeds:** small and light blackish-brown seeds that are easily carried away by the wind, and grow with a wide spread.

Vernacular Name : in Biak "Ruja", another designation is double deer.

Ecology: Ruja can grow well at an altitude of 500 meters above sea level. This plant is very competitive and requires high nutrients, especially N and P. Vegetatively reproducing through the stem and generative from seeds, the seeds will germinate after 30 days the pods break, germinating for 10 days will grow fast, and 8 months or more will produce pods with seeds.

B. Clasification Pim (*Melastoma malabathricum* (L))

Kingdom : Plantae
 Divisi : Tracheophytes
 Kelas : Angiosperms
 Ordo : Myrtales
 Famili : Melastomataceae
 Genus : Melastoma
 Spesies : *Melastoma malabathricum* L



Figure 8. Pim (*Melastoma malabathricum* (L))

3.5.2. Description of *Melastoma malabathricum* L. (Pim)

Shrub plants (Figure 8) with a height can reach 3 meters; **Leaves:** elliptical lanceolate in shape with a rounded base, reaching 7 cm in length, 2-4 cm in width, leaf boning consists of 3 main bonings parallel from the base to the apex; **Stem:** reddish covered with hairy scales and small hairs. **Flowers:** short terminal cymes with a diameter of 2 to 8 cm, pink, purple, or mauve color. **Fruits:** berries, cracked during irregular ripening

Vernacular Name : Biak "Pim" with besides that also known as Karamunting

Ecology: grows wild on a wide variety of soils, from sea level to an altitude of 3000 meters. This plant is native to Indomalaya, Japan, and Australia, and is usually found between 100 and 2,800 m in sparse meadows and secondary forests.

4. Conclusion

The dye plants that are used by the Byak tribe are 8 species: *Asytasia gangetica* (Ruja), *Melastoma maladaththricum* (Pim), *Arcangelisia flava* (Inggamines), *Morinda citrifolia* (Kandarek), *Philanthus sp.* (Sewu), *Macaranga tessellate* (Sapiyai), *Mallotus floribundus* (Barnesem), and *Bruguiera gymnorhiza* (Aibon).

All the dye plants include seven families, namely *Acanthaceae*, *Melastomaceae*, *Menispermaceae*, *Rubiaceae*, *Phylanthaceae*, *Euphorbiaceae* and *Rhizophoraceae*. The process of making natural dyes in the Byak tribe traditionally consists of three steps: the boiling process, the process of being ground or grounding, and the process of scraping and using directly by mixing additional ingredients such as lime or charcoal

Almost all natural dyes of the Byak tribe are used in wood media, both bark fibers and wood surfaces, with the types of wood applied, namely *Melochia umbellate* in Biak (Warmas), *Juncus effuses* (Madwes), for wood surfaces used types *Palaquium sp* (Moref), *Albizia chinensis* (Andai) and *Alstonia scholaris* (Maren).

The species that are often used are both *Asytasia gangetica* (L) or Ruja in Byak name and *Melastoma malabathricum* L. or Pim in Byak name. The species is easy to plant and grow. Both of them live in a wide variety of soil. These two species have the prospect to develop to produce some material natural dyes.

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STATEMENTS OF SOURCES

I hereby declare that I consent to the use of photographs in the research Natural dyes used by the byak tribe and its prospects as raw materials for the natural dyes industry which belongs to the author research and to local people in Biak with the signature in the below.

A handwritten signature in black ink, appearing to read 'Abraham' followed by a stylized flourish.

Abraham Warnares

A handwritten signature in black ink, appearing to read 'Nataniel' followed by a stylized flourish.

Nataniel Miosido