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Diversity Analysis Using Morphological Characteristics of '*Katuray*' (*Sesbania grandiflora* L.) in La Union Province, Philippines

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ABSTRACT

Hummingbird (*Sesbania grandiflora* L.), commonly known as 'katurai' or 'katuray' is an underutilized leguminous crop that contributes significantly to national food security and the livelihoods of small-scale farmers in the developing world. Despite its potential economic significance, it has not been fully known in La Union Province due to a lack of information on the genetic background of the cultivated landraces. Therefore, the main objective of this study was to assess the morphological diversity of 40 'katuray' accessions in La Union province using morphological characters. A total of 15 qualitative traits and 13 quantitative traits were assessed. The qualitative traits showed intermediate diversity with an average diversity index of H'=0.39, whereas the quantitative traits have an average diversity index of H'=0.63. Among 15 qualitative traits, 4 traits scored high diversity, namely, height of mature tree (H'=0.66), tree growth habit (H'=0.86), midrib color (H'=0.95), and flower color (H'=0.97). Meanwhile, most of the quantitative traits showed intermediate to high diversity among 'katuray' accessions. This is supported by the result of the Unweighted Pair Group Method with Arithmetic mean (UPGMA), which generated a dendrogram that distinctly grouped the 40 'katuray' accessions into six major clusters based on qualitative and quantitative morphological traits. Unique characteristics were also determined, namely, red and pink color of flower, and the black in seed color. The preliminary results of this study revealed that 'katuray' accessions in La Union province are diverse.

Keywords: diversity, legumes, morphology, mapping, underutilized crop

1. INTRODUCTION

High prices of accessible staple foods and governmental limits on food imports have been significant causes of the worsening food situation in developing nations (Weaver, 2014). In the Philippines, there is a growing interest in researching underused legumes to alleviate hunger and malnutrition, particularly among children and pregnant women (Chel-Guerrero et al., 2002; Arinathan et al., 2003; Coulter et al., 2008). One of the underutilized legumes that have the potential to alleviate malnutrition is Sesbania grandiflora L. This crop is among the underutilized legumes with comparable amounts of protein, essential amino acids, polyunsaturated fatty acids (PUFAs), dietary fiber, essential minerals and vitamins, and the presence of beneficial bioactive compounds to other

common legumes. Aside from that, these plants are adaptable to harsh environmental conditions and can thrive under extreme stress (Bhat et al., 2008; Sotelo et al., 2009; Amubode & Fetuga, 2013).

Sesbania grandiflora L. also known as 'katuray' belongs to the family Leguminosae under the tribe Robinieae and comprises about 60 tropical and subtropical species of herbs, shrubs, or small trees (Mabberley, 2007; Veasey et al., 2009). It has a close relationship with *S. formosa*, which is a known Australian species. The leaves and flowers of the 'katuray' plant are not traded like other significant market goods because it is not a commercial crop. Instead, it grows alongside important crops and in kitchen gardens, providing a meager subsistence. Occasionally, bundles of 'katuray' leaves and flowers can be seen in local markets, which is likely to satisfy the older generation who insists on the plant's many health advantages. Even though some traditional dishes use flowers, it seems as though their inclusion was motivated more by necessity than by flavor (Karmakar et al., 2016). 'Katuray' flowers are frequently made as a salad and served as an appetizer in the Philippines. Although this crop is rich in nutrients, it is not prioritized by most people due to its unpleasant taste (Karmakar et al., 2016). 'Katuray' is thought to be diverse and is made up of several kinds of trees. It has rectangular, 1.5–10 cm long, red, pink, and white flowers on lax, 2-4 flower racemes (Raja et al., 2018). Consumer interest in this neglected crop may be mounting, but more study is needed to uncover all its potential applications and distinctive qualities.

Morphological characterization has been regarded as a primary approach for improving comprehension of its morphological variation and determining genotype relationships (Karp et al., 2017). Morphological descriptors are also the most utilized for natural variation characterization and identification (Nurul et al., 2014; Chanda et al., 2019). Calimpang et al. (2024) use morphological characteristics to analyze the diversity of mango accessions. Furthermore, improved knowledge of morphological characterization may aid in long-term selection gain (Chowdhurry et al., 2022). Morphological features are traditionally used to assess genetic divergence and characterize existing germplasm materials. On the other hand, this technique offers a low-level but powerful taxonomic tool that has been used for preliminary categorization of germplasm prior to characterization using more accurate marker technologies. According to Din et al. (2010), the scientific classification of plants is still based on morphological characteristics. Furthermore, this technique is simpler, less expensive, easier to score, and requires no technical knowledge. Hence, this study aimed to assess the morphological diversity of 'katuray' in La Union Province.

2. MATERIALS & METHODS

2.1. Site Selection

The 'katuray' accessions were characterized at the nineteen (19) municipalities and one (1) city of La Union province (Table 1). At least 2-3 species were served as samples and characterized, depending on the availability of species in the area.

Table 1. List of 'katuray' Accessions Collected in La Union Province.

Accessions	Locations
Bacnotan 00122	Barangay Pangpang, Bacnotan
Bacnotan 00222	Barangay Baqui, Bacnotan
Sudipen 00322	Barangay Ilocano, Sudipen
Sudipen 00422	Barangay Old Central, Sudipen
Balaoan 00522	Barangay Apatut, Balaoan
Balaoan 00622	Barangay Masupe, Balaoan
Santol 00722	Barangay Paagan, Santol
Santol 00822	Barangay Corro-oy, Santol

San Gabriel 00922	Barangay Bumbuneg, San Gabriel
San Gabriel 001022	Barangay Lipay Norte, San Gabriel
Bangar 001122	Barangay Luzong Sur, Bangar
Bangar 001222	Barangay Sinapangan Sur, Bangar
Luna 001322	Barangay Magsiping, Luna
Luna 001422	Barangay Napaset, Luna
San Juan 001522	Barangay Cabaraoan, San Juan
San Juan 001622	Barangay Legleg, San Juan
San Fernando 001722	Barangay Cabaraoan, San Fernando
San Fernando 001822	Barangay Catbangen, San Fernando
Bauang 001922	Barangay Payocpoc Sur, Bauang
Bauang 002022	Barangay Disso-or, Bauang
Naguilian 002122	Barangay Balecbec, Naguilian
Naguilian 002222	Barangay Cabratitan Sur, Naguilian
Caba 002322	Barangay Urayong, Caba
Caba 002422	Barangay San Jose, Caba
Agoo 002522	Barangay San Antonio, Agoo
Agoo 002622	Barangay Macalva Sur, Agoo
Aringay 002722	Barangay San Eugenio, Aringay
Aringay 002822	Barangay Poblacion, Aringay
Santo Tomas 002922	Barangay Linong, Santo Tomas
Santo Tomas 003022	Barangay Casilagan, Santo Tomas
Tubao 003122	Barangay Gonzales, Tubao
Tubao 003222	Barangay Pideg, Tubao
Rosario 003322	Barangay Alipang, Rosario
Rosario 003422	Barangay Damortis, Rosario
Pugo 003522	Barangay Duplas, Pugo
Pugo 003622	Barangay Saytan, Pugo
Burgos 003722	Barangay Agpay, Burgos
Burgos 003822	Barangay Libtong, Burgos
Bagulin 003922	Barangay Cardiz, Bagulin
Bagulin 004022	Barangay Tagudtud, Bagulin

2.2. Morphological Characterization

The selected S. grandiflora accessions in every municipality were characterized using the modified descriptor list from various leguminous crops. The characterization employed qualitative and quantitative traits. The quantitative data are the following namely, height of mature tree, trunk circumference, crown diameter, length of petiole, leaflet length, leaflet number, midrib color, flower characteristics such as standard length, standard width, keel length and keel width, pod length, seed characteristics such as seed length, seed width, and number of seeds per pod. While, the qualitative data are the tree type, crown shape, tree growth habit, foliage density, leaf color, thickness of petiole, leaf waxiness, leaflet surface below, leaflet surface margin, flower color, number of flowers per inflorescence, number of pods per peduncle, pod dehiscence, and seed color (Table 2). The characterization is employed only in the tree types, leaves, flowers, and seeds.

Table 2. Morphological Characteristics of *Sesbania grandiflora* L.

Qualitative traits	Quantitative traits
Tree type	Height of mature tree
Crown shape	Trunk circumference
Tree growth habit	Crown diameter
Foliage density	Length of petiole
Leaf color	Leaflet length
Thickness of petiole	Leaflet number
Leaf waxiness	Flower length

Leaflet surface below	Flower width
Leaflet surface margin	Keel length
Midrib color	Keel width
Flower color	Pod length
Number of flowers per inflorescence	Seed length
Pod dehiscence	Seed width
Seed color	Number of seeds per pod

2.3. Mapping

During the characterization in the field, gathering of the coordinates in every species was also recorded using a Geocam application. According to Calimpang et al. (2024), mapping the diversity of accessions in the area should be done for easier monitoring and access of plant breeders for breeding purposes. All coordinates were encoded in Excel and processed using QGIS to develop a geographical map.

STATISTICAL ANALYSIS

The morphological characters were analysed using the phenotypic diversity as estimated by the standardized Shannon Weaver's Diversity Index (H') using the formula:

$$H' = \frac{-\Sigma_{i=1} Pi (\log_2 Pi)}{\log_2 n}$$

where:

n= the number of phenotypic classes for a character.

Pi= the proportion of the total number of entries belonging to the ith class.

The diversity index criteria of Eticha et al. (2005) and Jamago and Cortes (2012) were followed.

$H2 \geq 0.67$= high

$0.34 \leq H' \leq 0.66$ = intermediate

$0.01 \leq H' \leq 0.33$= low

3. RESULT

3.1. Morphological characters

In this study, 40 accessions of 'katuray' were scored and measured using 15 qualitative and 13 quantitative morphological characters. The morphological characters of 'katuray' species showed high, medium and no diversity in both qualitative and quantitative traits (Table 4 & 5). Among the qualitative characters scored, tree type, crown shape, leaf color, leaflet surface below, leaflet surface margin, number of pods per peduncle, and pod dehiscence observed with no diversity. On the other hand, Four out of 15 qualitative traits scored had a high diversity with an average index of 0.86 (Table 4). Intermediate diverse traits were also observed for 4 descriptors: foliage density, petiole thickness, leaf waxiness and seed color with indices ranging between 0.36-0.43. Overall, the diversity in qualitative traits was intermediate with an average diversity index of H'=0.39

Table 4. Qualitative Morphological trait differences among 'katuray' Accessions (n=40).

Qualitative traits	Common trait	Unique trait	H'	Diversity
Height of mature tree	Medium		0.66	High
Tree growth habit	Erect		0.86	High
Midrib color	Absent		0.95	High
Flower color	White	Red	0.97	High
Foliage density	Intermediate		0.42	Intermediate
Thickness of petiole	Thin		0.42	Intermediate
Seed color	Orange brown	Black	0.36	Intermediate
Leaf waxiness	Weak		0.43	Intermediate
Tree type	Seedling		0	No diversity
Crown shape	Broadly pyramidal		0	No diversity
Leaflet surface below	Smooth		0	No diversity
Leaflet surface margin	Smooth		0	No diversity

Leaf color	Light green		0	No diversity
Number of pod per peduncle	Twin pod per peduncle		0	No diversity
Pod dehiscence	<10% dehiscence		0	No diversity
Average			0.39	

Table 5 sums up the quantitative morphological characters showing the highest to lowest values measured for each character. Most of the traits had high diversity indices of 0.80 (Table 4). Traits with high diversity are trunk circumference (cm), crown diameter (m), leaflet length, standard length, standard width, keel length, keel width, pod length, seed length, and seed width. Three descriptors showed intermediate diversity of H'=0.64. These intermediate characteristics were petiole length, leaflet number, and number of seeds per pod. In the case of vegetative traits, leaflet length (H'=0.77) showed the maximum value of diversity index, followed by petiole length (H'=0.64), whereas minimum diversity index was recorded in leaflet number (H'=0.45). Among all the floral traits, the highest index diversity was displayed by standard with (H'=0.86) followed by keel length (H'=0.85) and standard length (H='0.83) and the lowest value was demonstrated in keel width (H='0.79). Considering plant traits, the maximum diversity index was observed in pod length (H'=0.84), followed by seed length (H'=0.80), whereas the minimum value of diversity index was exhibited by seed width (H'=0.76) and number of seeds per pod (H'=0.66).

Table 5. Quantitative Morphological trait differences among *Sesbania grandiflora* L. Accessions (n=40).

Quantitative traits	**Highest**	**Lowest**	**H'**	**Diversity**
Trunk circumference (cm)	42.19	11.09	0.87	High
Crown diameter (m)	1.92	0.70	0.71	High
Leaflet length	27.56	18.38	0.78	High
Standard length	9.77	7.62	0.83	High
Standard width	4.20	2.42	0.86	High
Keel length	8.63	7.03	0.85	High
Keel width	3.31	1.63	0.79	High
Pod length	32.77	21.89	0.84	High
Seed length	0.88	0.45	0.81	High
Seed width	0.42	0.22	0.76	High
Length of petiole	1.63	1.23	0.64	Intermediate
No. of seeds per pod	24.09	16.56	0.66	Intermediate
Leaflet number	37.05	24.83	0.45	Intermediate

3.2. Cluster Analysis of Morphological Traits

Based on Pearson's similarity coefficient and using the UPGMA method, the dendrogram divided the 40 'katuray' accessions into six (6) major clusters (Figure 1).

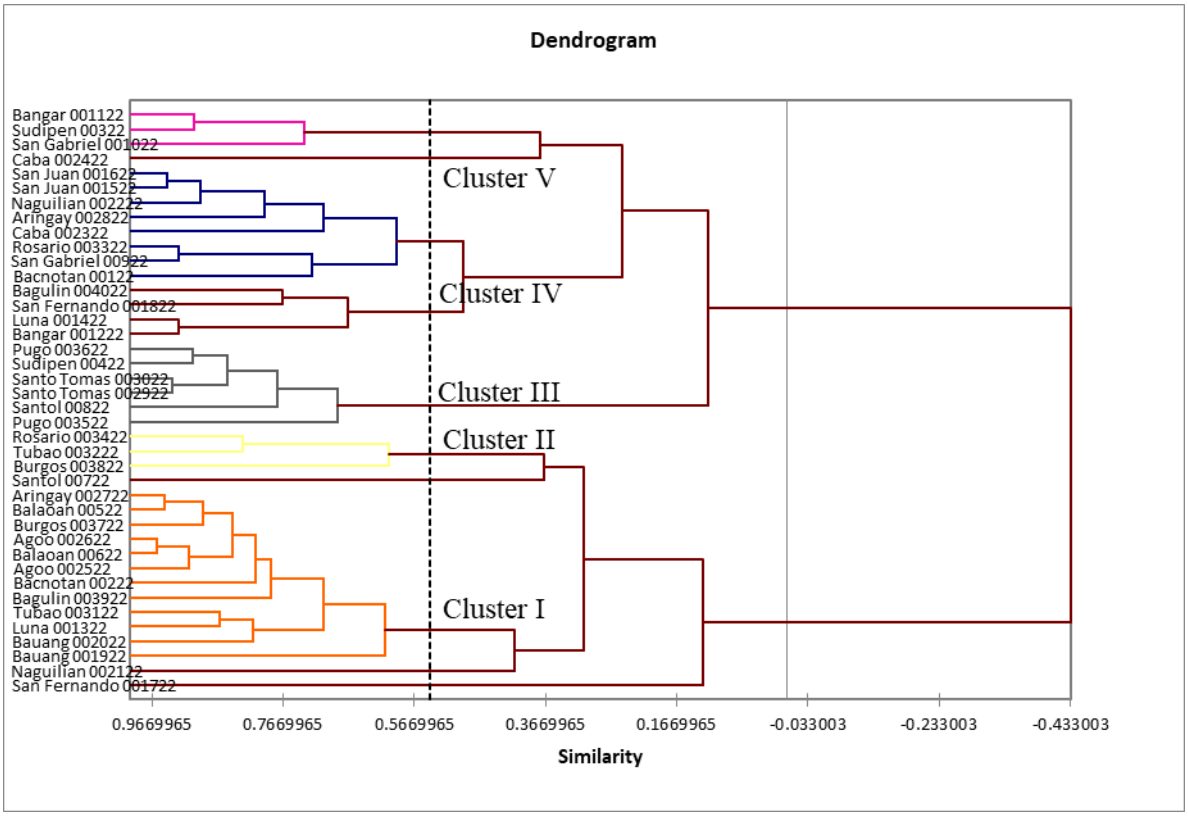

Figure 1. Dendrogram of the Agglomerative Hierarchical Clustering (AHC) for the 40 'katuray' accessions based on 28 morphological traits.

Cluster I was the largest which was composed of 14 accessions, Aringay 002722, Balaoan 00522, Burgos 003722, Agoo 002622, Balaoan 00622, Agoo 002522, Bacnotan 00222, Bagulin 003922, Tubao 003122, Luna 001322, Bauang 002022, Bauang 001922, Naguilian 002122, and San Fernando 001722 were grouped based on the flower color.

Cluster II, Rosario 003422, Tubao 003222, Burgos 003822, and Santol 00722 were grouped which are very diverse, as they belong to different origins, adaptability, and maturity duration. However, all these were characterized with having intermediate foliage density, thin petioles, and leaf waxiness. Cluster III was Pugo 003622, Sudipen 00422, Santo Tomas 003022, Santo Tomas 002922, Santol 00822, and Pugo 003522, with commonly shared traits for a sparse foliage density, and having orange-brown seed color. Bagulin 004022, San Fernando 001822, Luna 001422, and Bangar 001222 were clustered in Cluster IV based on the number of flowers per inflorescence. Cluster V was composed of 8 accessions grouped, namely: San Juan 001622, San Juan 001522, Naguilian 002222, Aringay 002822, Caba 002322, Rosario 003322, San Gabriel 00922, as well as Bacnotan 00122, having common shared traits in pod dehiscence. While Cluster VI includes 4 accessions (Bangar 001122, Sudipen 00322, San Gabriel 001022, and Caba 002422) that were confirmed to have a common trait on the thick petiole.

3.3. Map of the La Union showing the collection site of 'katuray' accessions

Geographical mapping of 'katuray' is shown in Figure 2, which shows the distribution of the 'katuray' trees in the different parts of La Union Province.

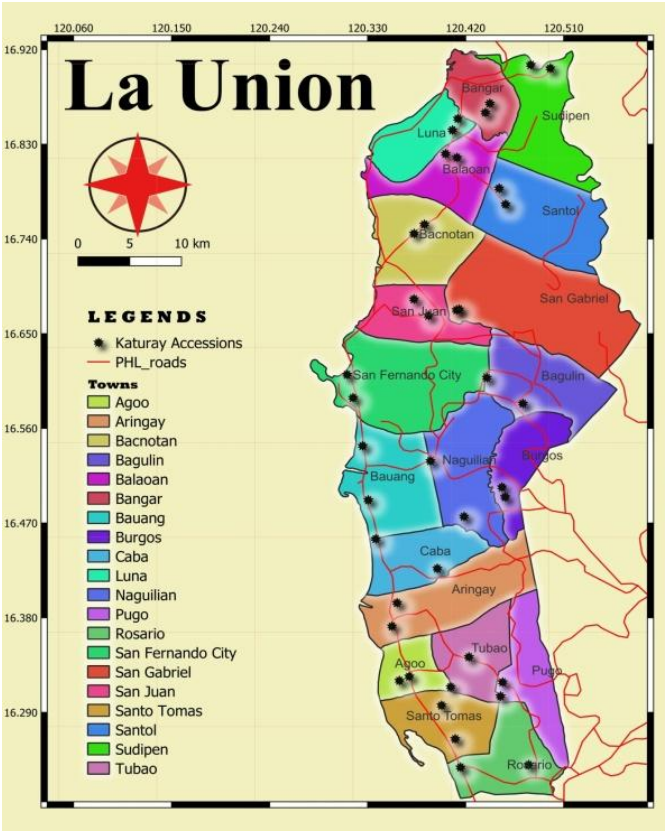

Figure 2. Map of La Union Province showing the collection sites of 'katuray' Accessions

'Katuray' flower with a red color has been observed in fifteen (15) barangays from various municipalities in La Union with 37.5% out of 40 accessions. The barangays were Pangpang Bacnotan, Ilocano Sudipen, Luzong Norte Bangar, Cabaroan San Juan, Cabaroan San Fernando, Cabaritan Sur Naguilian, San Jose Caba, San Antonio Agoo, San Eugenio Aringay, Linong Santo Tomas, Gonzales Tubao, Alipang Rosario, Duplas Pugo, Agpay Burgos and Cardiz Bagulin. Six (6) barangays in La Union were also found to have slightly pink *katuray* flowers, with 15% out of 40 accessions that had been cultivated. Barangays were Baqui Bacnotan, Masupe Balaoan, Paagan Santol, Bumbuneg San Gabriel, Magsiping Luna, Payocpoc Sur Bauang. White *katuray* flowers were also found in nineteen (19) barangays in La Union, with 47.5% out of 40 accessions. They are Old Central Sudipen, Apatut Balaoan, Corro-oy Santol, Lipay Norte San Gabriel, Sinapangan Sur Bangar, Napaset Luna, Legleg San Juan, Catbangen San Fernando, Disso-or Bauang, Balecbec Naguilian, Urayong Caba, Macalva Sur Agoo, Poblacion Aringay, Casilagan Santo Tomas, Pideg Tubao, Damortis Rosario, Saytan Pugo, Libtong Burgos, Tagudtud Bagulin.

DISCUSSION

An important stage in crop improvement is the evaluation of morphological diversity and crop interactions. Crop genetic variety, on the other hand, requires a complete understanding of their properties, and morphological qualities have been utilized as a good reference for investigating genetic variation in crop plants, which is of considerable interest to plant breeders (Mohammadi and Prasanna, 2017).

Forty (40) 'katuray' accessions were scored and quantified using 15 qualitative and 13 quantitative morphological features in this study. 'Katuray' species' morphological features revealed high, medium, and little variety in both qualitative and quantitative traits (Tables 4 and 5). No diversity result in qualitative traits was similar to the findings

of Chanda et al. (2019) investigated the agro-morphological characteristics of *S. bispinosa*. It suggests that characteristics are primarily genetically controlled, with minimal effect from settings or locales. Four of the 15 qualitative features rated, on the other hand, had a significant degree of variation, with an average index of 0.86 (Table 4). According to the findings of Chanda et al. (2019), who estimated the variation in agro-morphological descriptors of *S. bispinosa*, it shows that seeds harvested from several districts have substantial genetic variety. The large variances between the study locations showed that this variability could be used further in crop enhancement initiatives.

With indices ranging from 0.36-0.43, intermediate varied features were identified for four descriptors. This was similar to the study of Manyassa et al. (2009) who discovered a moderate variability in seed color and leaf design. In general, the observed heterogeneity is often determined by its natural out-crossing rate (Upadhyaya et al., 2007) and varies according to location, genotype, insect population intensity, and flowering period (Reddy et al., 2004).

Table 5 summarizes the quantitative morphological features, from highest to lowest measured values for each character. The majority of the features have high diversity indices of 0.80 or above (Table 4). Sarwar et al. (2015) found that unnamed *Sesbania* accessions showed a considerably wider variety in floral and fruit morphological characteristics, which could be attributed to the accessions' natural hybrid nature. Three descriptors had H'=0.64 intermediate diversity. This distribution pattern produced results similar to those obtained by Getachew et al. (2013). The identical outcome could be attributed to quantitative qualities being highly heritable and less impacted by environmental influences.

To analyze the genetic resemblances among the accessions, agglomerative hierarchical clustering (AHC) based on Pearson's similarity coefficients was calculated, and the similarity coefficient matrix was used for the UPGMA cluster. The dendrogram classified the 40 'katuray'accessions into six (6) primary groups based on Pearson's similarity coefficient and the UPGMA method. The findings of this study concur with the study of Mohan et al., (2019), who found genetic diversity among Sesbania accessions genotypes and clustering based on various morphological features. These findings were also supported by the findings of Win et al. (2020), who assessed genetic diversity among Sesbania accessions using 79 multivariate analyses, and the genotypes in their study were grouped into three clusters based on agro-morphological traits. Although the germplasm analysed was obtained from various places in La Union, it shared several physical attributes, indicating that the clustering in this study did not always reflect the geographic origin of the accessions.

CONCLUSION

The morphological variation of 'katuray' in La Union province showed intermediate diversity based on qualitative traits, while quantitative traits have intermediate to high diversity. This was clustered into six groups with diverse locations, which implies that all the 'katuray' in the province may share similar characteristics among others. Most of the katuray accessions characterized in La Union province are 47.5% white flowers, which most people prefer for food preparations.

Declaration by Authors

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