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PAPER

Data Mining Application for the Spread of Endemic Butterfly Cenderawasih Bay using the K-Means Clustering Algorithm

Fegie Y. Wattimena[1], Abilliyo S. Mampioper[1], Reni Koibur[1], I. Nyoman G. A. Astawa[2], Dony Novaliendry[3](✉), Noper Ardi[4], Nenny Mahyuddin[3]

[1]Faculty of Science & Technology, University of Ottow Geissler, Papua, Indonesia

[2]Electrical Engineering Major, Bali State Polytechnic, Bali, Indonesia

[3]Universitas Negeri Padang, Padang, Indonesia

[4]Department of Informatics Engineering, Politeknik Negeri Batam, Batam, Indonesia

dony.novaliendry@ft.unp.ac.id

ABSTRACT

The superfamily Papilionoidea day butterfly, which is endemic to the Cenderawasih Bay islands (Numfor, Supiori, Biak and Yapen), consists of 6 family species: the Papilionidae, Hesperiidae, Pieridae, Riodinidae, Lycaenidae and Nymphalidae families. This study aims to analyze the grouping of endemic butterflies of the Bay of Cendrawasih based on wings and colours in 4 Clusters, namely Numfor, Supiori, Biak and Yapen Islands, by applying the function of the K-Means Clustering algorithm data mining method. The grouping selection was carried out 7 times with the conclusion that Numfor had 13 types of Endemic Butterfly species, Biak had 7 Papuan Endemic Butterfly Species, Supiori had 9 Endemic Butterfly Species, and Yapen had 11 Endemic Butterfly Species. The analysis results were then retested in an application built using the Waterfall system development method and the PHP and MySQL programming languages. In addition to applying the K-Means Clustering algorithm for grouping endemic butterflies, the application created produces a butterfly distribution map that displays butterfly information based on family.

KEYWORDS

Papilionoidea, butterfly, Cendrawasih Bay Island, K-Means Clustering

1 INTRODUCTION

The distribution of butterflies worldwide is extensive in almost all habitats, where plants provide food and shelter [1]. The Antarctic region is the only place where butterflies are not found, especially from members of Lepidoptera [2]. Among the factors that limit the spread of butterflies are geology, suitable ecological conditions and the distribution of host plants that feed butterflies in their adult and larval stages [3]. Butterflies can even be found in almost all habitats if they have host plants suitable for the kind of butterfly [4]. However, from various studies, it is also known that

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there are endemic butterfly species whose distribution is limited to certain places, such as Trogonoptera and Ornithoptera species. Besides being endemic, cosmopolitan butterflies have a wide distribution and quickly adapt to various environmental conditions, such as the Papilio Memnon species [3]. Numfor, Supiori, Biak and Yapen are islands in the Cenderawasih Bay area of Papua Province that need special attention because they have a relatively high level of butterfly endemicity. Butterfly species can develop into subspecies or even new species. Therefore, it is unsurprising that the islands of Cenderawasih Bay found several endemic species and subspecies. Species of the day butterfly Superfamily Papilionoidea, which is endemic to the Cenderawasih Bay islands (Numfor, Supiori, Biak and Yapen), consists of 6 family species, namely Family Papilionidae, Family Hesperiidae, Family Pieridae, Family Riodinidae, Family Lycaenidae and Family Nymphalidae [5].

The utilization of information technology today can help to facilitate the grouping of various species, which previously could only be done using manual or semi-computer methods [6]. This technology can also be applied to help classify the types of butterflies and the distribution areas of these butterfly species. The grouping of butterflies endemic to the Cendrawasih Bay area based on these 4 areas is needed for inventory and observation. The process of the group required the application of data mining functions. Data mining is an activity to find interesting patterns from large amounts of data, and data can be stored in databases, data warehouses, or other information stores [7]. One of the data mining methods used in this study is the K-Means Clustering algorithm [8][9][10][11]. By using this method, the endemic butterfly data that have been obtained are grouped into several clusters, and then literacy is carried out to get the grouping results that do not change. Furthermore, the researchers designed a data mining application for the distribution of butterflies using the Waterfall process model, which can provide information in the form of butterfly data input, K-Means calculations, butterfly distribution maps and butterfly searches based on family [12][13].

2 METHODOLOGY

a. The Thinking Framework in this study is described as follows:

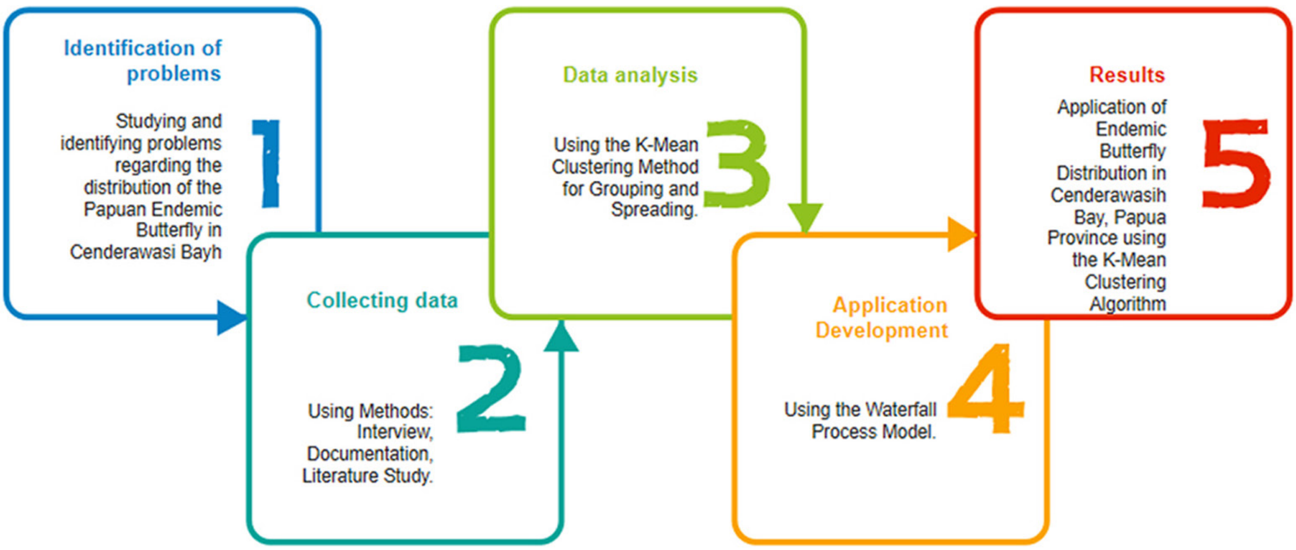

Fig. 1. Research Framework

From Figure 1 which discusses the research framework, it can be explained that in the first step we have to identify the problem regarding the Distribution of Endemic Butterflies in Cenderawasih Bay followed by existing data, then analyze the data using clustering using waterfall modeling. After that, the results of the application program will be obtained.

b. The data mining analysis method used in this research is using the K-Means Clustering Algorithm [14][15][16][17][18][19]:

1) Determine the number of k-clusters to be formed.

2) Generating Random values for the initial k-cluster centre (centroid).

3) Calculate the distance of each input data to each centroid using the distance formula (Euclidean Distance) so that the closest distance from each data to the centroid is found. The following is the Eucledian Distance equation:

$$D(ij) = \sqrt{(X_{1i} - X_{1j})^2 + (X_{2i} - X_{2j})^2} \quad (1)$$

Where:
$D(ij)$ = Data distance to (i) to cluster centre (j)
X_{1i} = Data to (i) on data attribute (k)
X_{2i} = Center point (j) on an attribute (k)

4) Classify each data based on its proximity to the centroid [20]. (smallest distance).

5) Update the centroid value. The new centroid value is obtained from the average of the cluster in question using the formula:

$$R_k = \frac{1}{N_k}(X_{1k} + X_{2k}) \quad (2)$$

R_k = New average
N_k = Number of training patterns in the cluster (K)
X_{nk} = Pattern to (n) that is part of the cluster (k)

6) Repeat step 2 until the members of each cluster do not change.

7) If step 6 has been met, then the average value of the cluster centre (μj) in the last literacy will be used as a parameter to determine the classification of the data

c. The system development method uses the waterfall process model [21][22] with the stages of analysis, design, coding [23][24][25] and testing, as shown in Figure 2

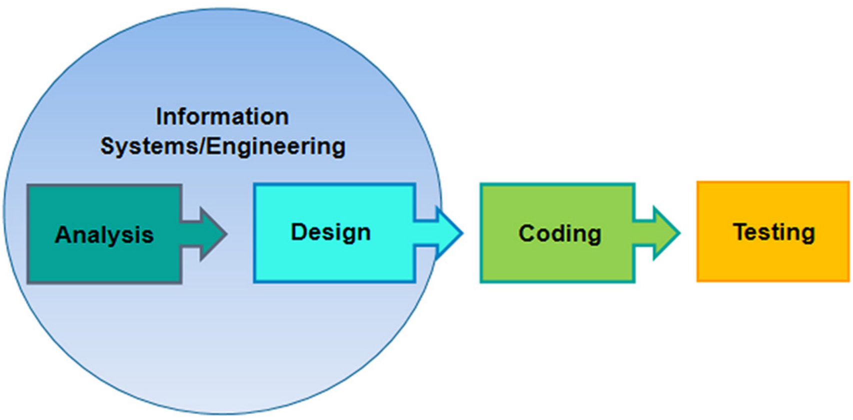

Fig. 2. Waterfall Process Model

3 RESULT AND DISCUSSION

a. Data analysis using the K-Means Clustering Algorithm method

1) Butterfly Wing Size and Color Grouping

Table 1. Butterfly Wing Size Value

Value	Wing Size
1	52–60 mm
2	43–51 mm
3	36–42 mm
4	25–37 mm
5	16–24 mm

Table 2. Butterfly Color Value

Value	Colour
1	Blue-Brown, Black-White, Grey-Yellow
2	Brown-White
3	Black-White, Yellow-Blue, Brown
4	Brown-Yellow, White-Black
5	White, Black-Blue

2) Attribute Value Grouping/Initial Cluster

Table 3. Initial Clusters/Attributes

Initial Clusters		Wings	Colour
C1	NUMFOR	1	1
C2	BIAK	4	5
C3	SUPIORI	4	4
C4	YAPEN	3	4

From the results of the initial cluster grouping it can be analyzed that the distribution of butterflies in Cenderawasih Bay is divided based on size which can be seen in Table 1, and the color of the wings which can be seen in Table 2, making it easier to group butterflies like in Table 3 with the highest degree of similarity in The initial cluster is determined as presented in Table 4 below.

3) Butterfly data grouping

Table 4. Butterfly data

No	Family	Genus	Species	Wings	Color
1	Papilionoideae	Papilio	Albinus	5	3
2	Hesperiidea	Hasora	Subcaelestis	1	5
		Sabera	Tabla	4	4
3	Pieridae	Elodina	Niaka	1	4
			Anticyra	4	2
		Pareronia	Chinki	5	5
		Delias	Biaka	5	1
			Euphemia	5	3
			Talboti	1	3
			Bosnikiana	4	1
			Maudei	4	1
			Dohertyi	4	2

(Continued)

Table 4. Butterfly data *(Continued)*

No	Family	Genus	Species	Wings	Color
4	Riodinidae	Dicallaneura	Princessa	3	4
5	Lycaenidae	Hypochrysops	Felderi	2	5
		Deudorix	Maudei	1	5
		Candalides	Tringa	3	1
			Silicea	1	3
			Meforensis	2	1
		Jamides	Nitens	2	1
6	Nymphalidae	Parantica	Melusine	1	5
		Ideopsis	Hewitsonii	2	3
		Euploea	Tripunctata	4	3
			Albicosta	5	1
		Morphosis	Albertisi	4	4
		Hyanthis	Hodeva	3	1
		Taenaris	Scylla	2	2
		Mycalesis	Valeria	3	4
			Giamana	1	4
			Comes	3	1
			Fulvianetta	4	2
		Harsiesis	Hygea	5	3
		Erycinidia	Maudei	1	4
		Cyrestis	Biaka	5	3
		Parthenos	Aspila	4	3
		Mynes	Websteri	5	3
		Cirrochroa	Imperatrix	1	4
		Algia	Felderi	4	5

4) Clustering Calculation

Table 5 is a calculation process to get the distance of all data to each cluster centre point. By using the Euclidean Distance Formula in formula 1.1, the following results are obtained:

Table 5. Initial Clustering Calculation

No	Species	C1	C2	C3	C4	Distance Nearest	Group Data
1	Albinus	8	5	2	3	2	3
2	Subcaelestis	16	3	4	3	3	2,4
3	Tabla	12	1	0	1	0	3
4	Niaka	9	4	3	2	2	4
5	Anticyra	4	9	4	5	4	1,3

(Continued)

Table 5. Initial Clustering Calculation *(Continued)*

No	Species	C1	C2	C3	C4	Distance Nearest	Group Data
6	Chinki	20	1	2	3	1	2
7	Biaka	4	17	10	11	4	1
8	Euphemia	8	5	2	3	2	3
9	Talboti	4	7	4	3	3	4
10	Bosnikiana	3	16	9	10	3	1
11	Maudei	3	16	9	10	3	1
12	Dohertyi	4	9	4	5	4	1,3
13	Princessa	11	2	1	0	0	4
14	Felderi	17	2	3	2	2	2,4
15	Maudei	16	3	4	3	3	2,4
16	Tringa	2	17	10	9	2	1
17	Silicea	4	7	4	3	3	4
18	Meforensis	1	18	11	10	1	1
19	Nitens	1	18	11	10	1	1
20	Melusine	16	3	4	3	3	2,4
21	Hewitsonii	5	6	3	2	2	4
22	Tripunctata	7	4	1	2	1	3
23	Albicosta	4	17	10	11	4	1
24	Albertisi	12	1	0	1	0	3
25	Hodeva	2	17	10	9	2	1
26	Scylla	2	11	6	5	2	1
27	Valeria	11	2	1	0	0	4
28	Giamana	9	4	3	2	2	4
29	Comes	2	17	10	9	2	1
30	Fulvianetta	4	9	4	5	4	1,3
31	Hygea	8	5	2	3	2	3
32	Maudei	9	4	3	2	2	4
33	Biaka	8	5	2	3	2	3
34	Aspila	7	4	1	2	1	3
35	Websteri	8	5	2	3	2	3
36	Imperatrix	9	4	3	2	2	4
37	Felderi	19	0	1	2	0	2

The results of the preliminary conclusions are described in Table 6, which is the process of grouping data based on the closest distance of the Butterfly to the centre of the Cluster.

Table 6. Conclusions on the initial data grouping

Conclusions		
C1	13 Data	5,7,10,11,12,16,18,19,23,25,26,29,30
C2	6 Data	2,6,14,15,20,37
C3	12 Data	1,3,5,8,9,12,22,24,30,31,33,34,35
C4	13 Data	2,4,9,13,14,15,17,20,21,27,28,32,36

By using the same steps, carried out 7 (seven) times literacy, the following results are obtained:

Table 7. Literacy of clustering criteria

No	Stages	Criteria	Amount of Data	Conclusion
1	Beginning	C1	13	5,7,10,11,12,16,18,19,23,25,26,29,30
		C2	7	3,6,13,14,24,27,37
		C3	9	1,3,8,22,24,31,33,34,35
		C4	11	2,4,9,14,15,17,20,21,28,32,36
2	Literacy 1	C1	13	5,7,10,11,12,16,18,19,23,25,26,29,30
		C2	7	3,6,13,14,24,27,37
		C3	9	1,3,8,22,24,31,33,34,35
		C4	11	2,4,9,14,15,17,20,21,28,32,36
3	Literacy 2	C1	15	5, 6, 7, 10, 11, 12, 16, 18, 19, 23, 25, 26, 29, 30, 37
		C2	8	2,6,13,14,15,20,27,37
		C3	13	1,3,5,6,8,12,22,24,30,31,33,34,35
		C4	11	2,4,9,15,17,20,21,26,28,32,36
4	Literacy 3	C1	13	5,7,10,11,12,16,18,19,23,25,26,29,30
		C2	8	2,6,13,14,15,20,27,37
		C3	9	1,3,8,22,24,31,33,34,35
		C4	10	2,4,9,15,17,20,21,28,32,36
5	Literacy 4	C1	13	5,7,10,11,12,16,18,19,23,25,26,29,30
		C2	5	6,13,14,27,37
		C3	9	1,3,8,22,24,31,33,34,35
		C4	10	2,4,9,15,17,20,21,28,32,36
6	Literacy 5	C1	13	5,7,10,11,12,16,18,19,23,25,26,29,30
		C2	7	3,6,13,14,24,27,37
		C3	9	1,3,8,22,24,31,33,34,35
		C4	11	2,4,9,14,15,17,20,21,28,32,36

(Continued)

Table 7. Literacy of clustering criteria *(Continued)*

No	Stages	Criteria	Amount of Data	Conclusion
7	Literacy 6	C1	13	5,7,10,11,12,16,18,19,23,25,26,29,30
		C2	7	3,6,13,14,24,27,37
		C3	9	1,3,8,22,24,31,33,34,35
		C4	11	2,4,9,14,15,17,20,21,28,32,36
8	Literasi 7	C1	13	5,7,10,11,12,16,18,19,23,25,26,29,30
		C2	7	3,6,13,14,24,27,37
		C3	9	1,3,8,22,24,31,33,34,35
		C4	11	2,4,9,14,15,17,20,21,28,32,36

From Table 7 of the calculation and grouping of the calculated data, the researcher found that the results of the sixth and seventh literacy results in the grouping of endemic butterfly data that does not change anymore. So that researchers can conclude the final results where the distribution of Papuan endemic butterflies are as follows: Numfor has 13 endemic butterfly species, Biak has 7 endemic butterfly species, Supiori has 9 endemic butterfly species, and Yapen has 11 butterfly species. -butterfly. -Butterflies Endemic to Papua, the percentage of butterfly distribution as shown in the graph presented in Figure 3 below:

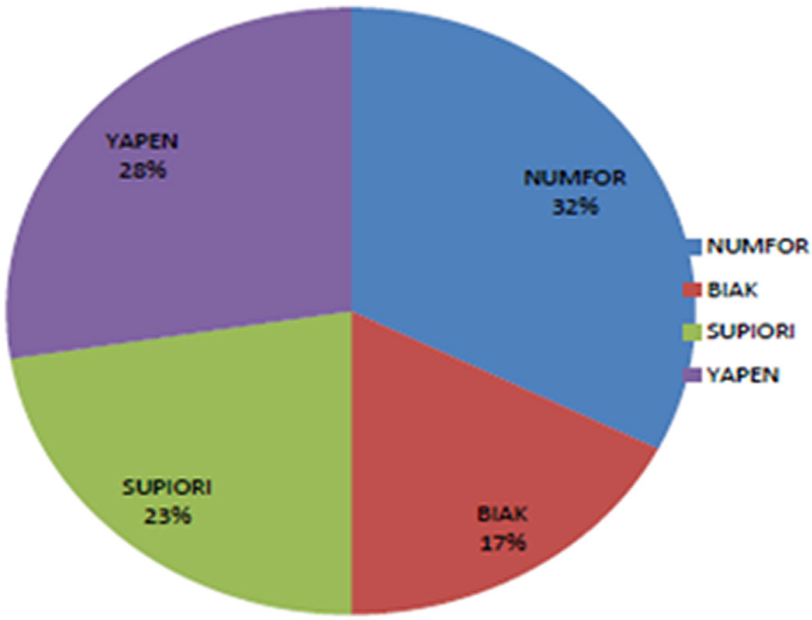

Fig. 3. Graph of the distribution of endemic butterflies

b. Implementation

After performing the analysis and system design stage, the next step is to apply the analysis and design results to the programming language. The results of the implementation in the PHP and MY SQL programming languages are as follows:

1) Attribute Menu Display

Figure 4 presents the Attributes menu for managing attribute data for endemic butterflies for use in clustering calculations.

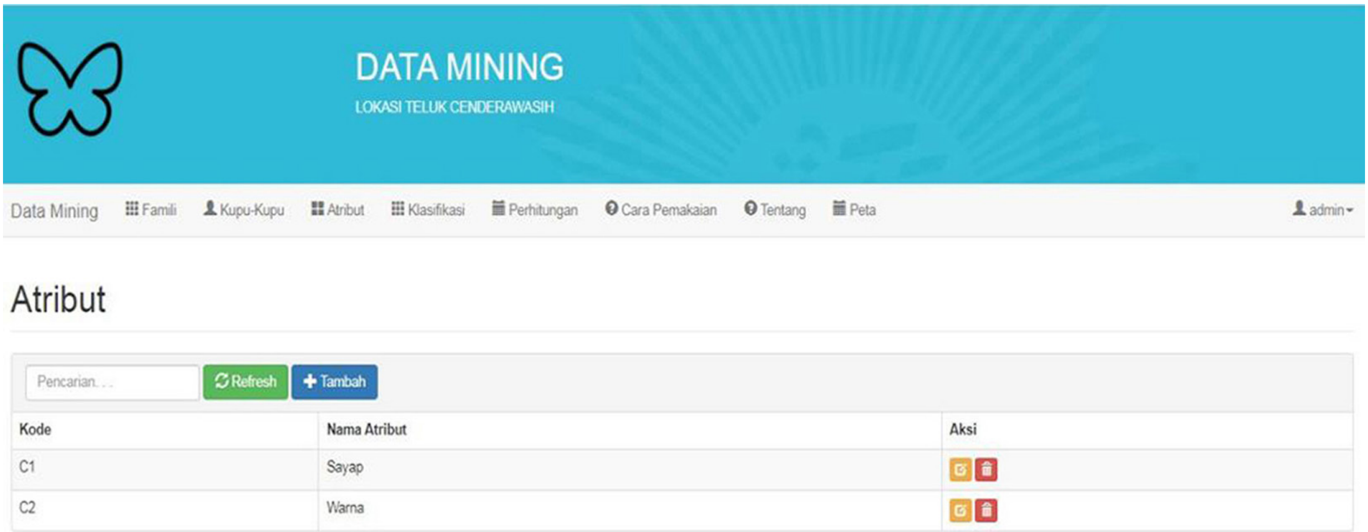

Fig. 4. Attribute Menu Display

2) Classification Menu Display

Figure 5 Presents the classification menu for the location of the butterfly presence area that has been calculated using the clustering method.

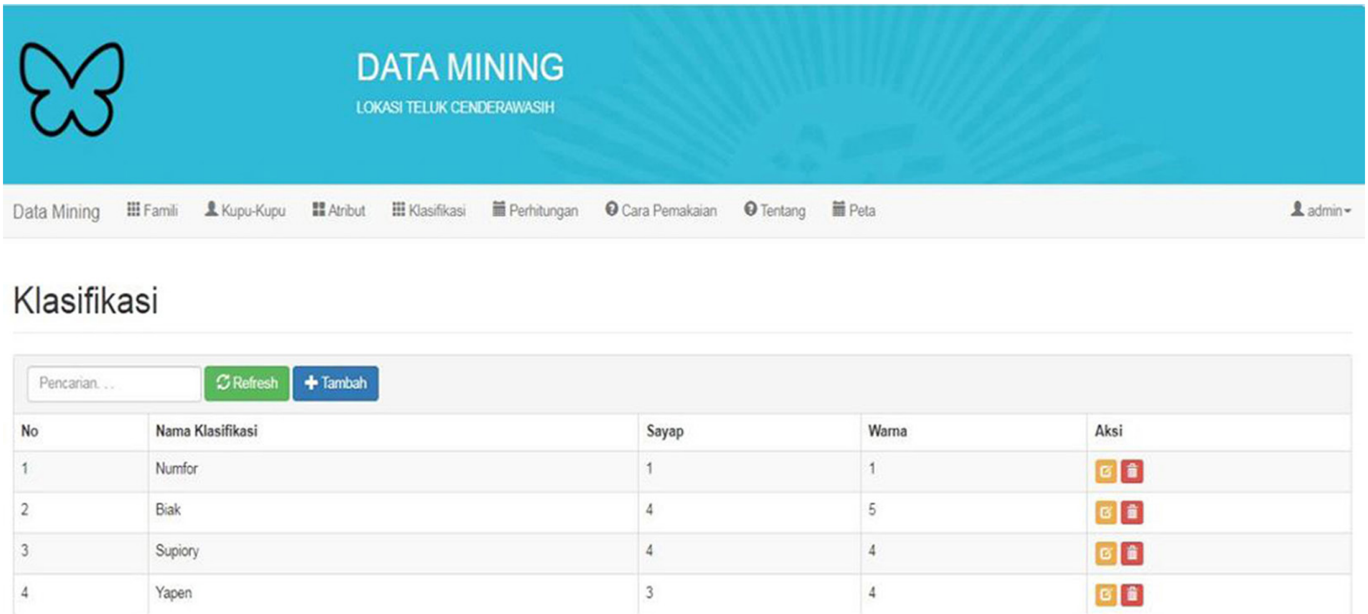

Fig. 5. Classification Menu Display

3) Butterfly Menu Display

In Figure 6 in the Butterfly Menu Display, the admin can manage detailed butterfly data that will be processed in the clustering system of the endemic butterfly distribution map.

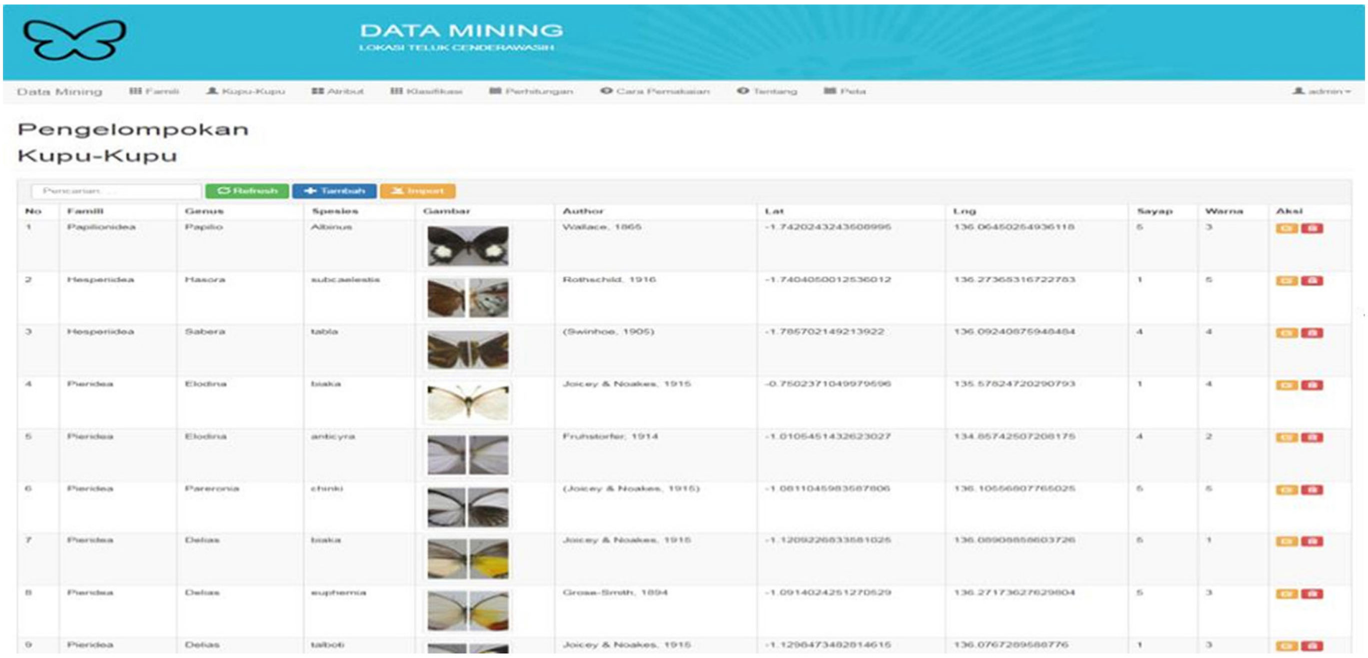

Fig. 6. Butterfly Grouping Menu Display

4) Calculation Menu Display

Figure 7 is a menu for performing the calculation process and result using the K-Means Clustering algorithm automatically by the system.

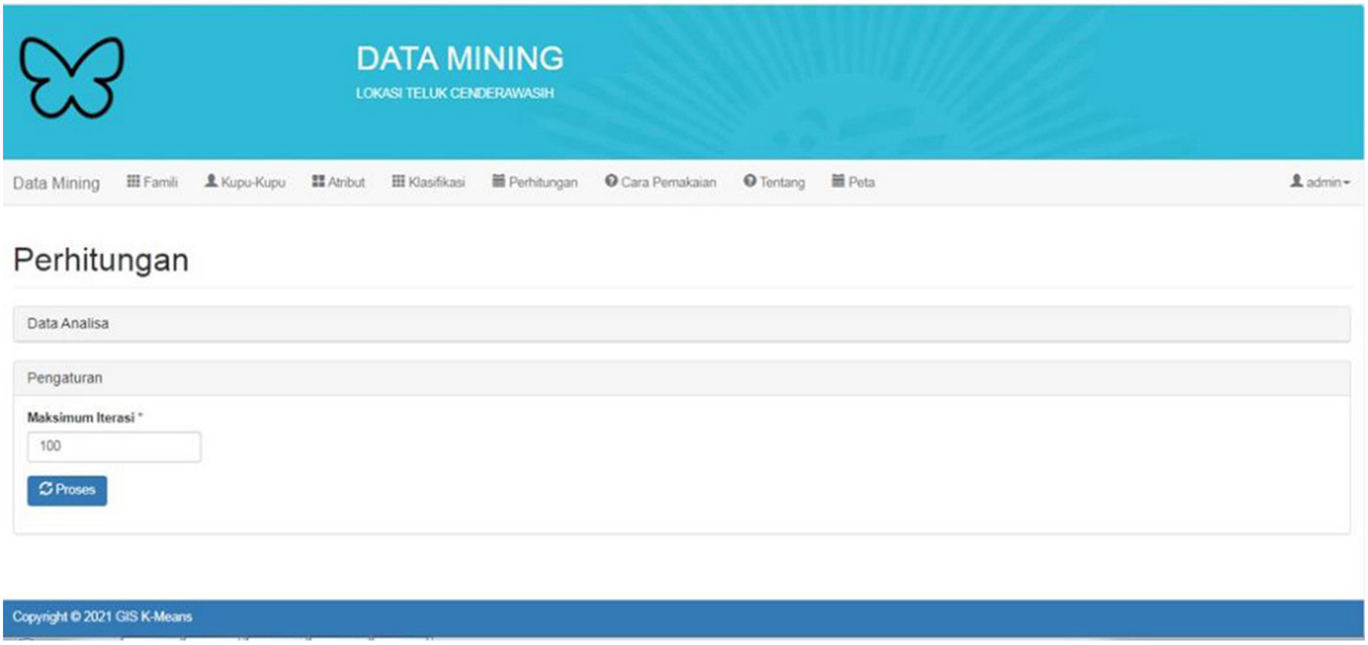

Fig. 7. Calculation Menu Display

5) Map of the distribution of endemic butterflies

The map display of the distribution of endemic butterflies based on the whole family and each family in the 4 Cendrawasih Bay areas of Papua Province is presented in the following figures (Figures 8–14):

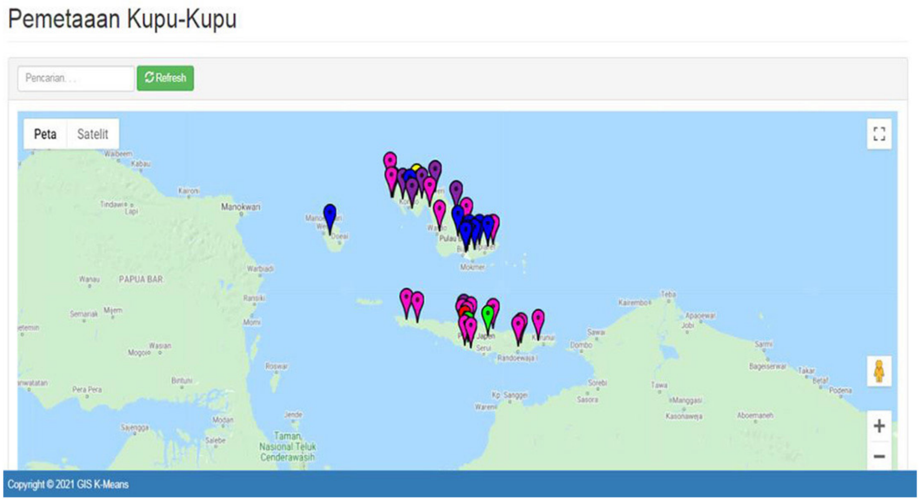

Fig. 8. Result Calculation Menu Display

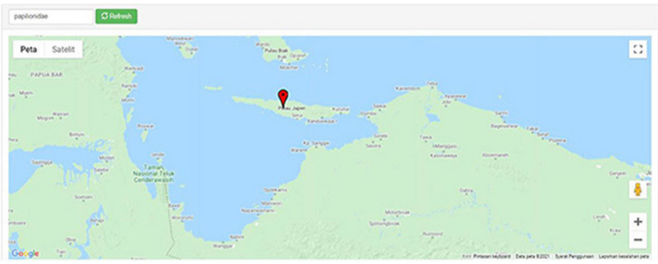

Fig. 9. The Distribution of Butterflies of the Papilionidae Family

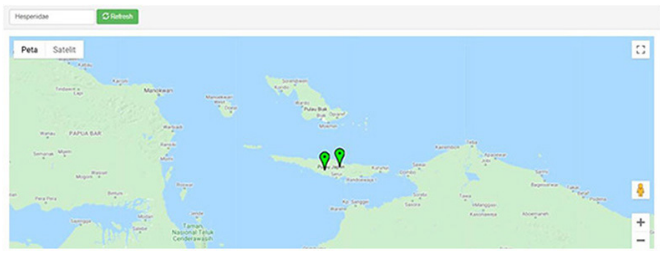

Fig. 10. The Distribution of Butterflies of the Hesperiidae Family

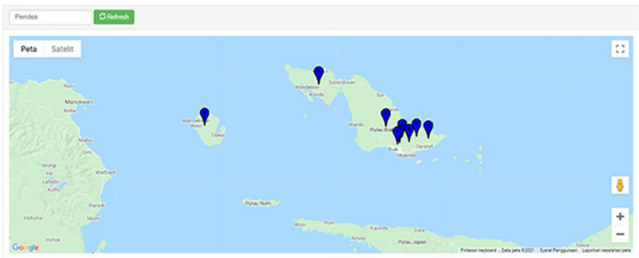

Fig. 11. The Distribution of Butterflies of the Pieridae Family

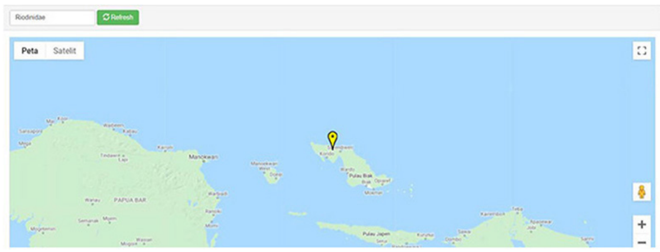

Fig. 12. The Distribution of Butterflies of the Riodinidae Family

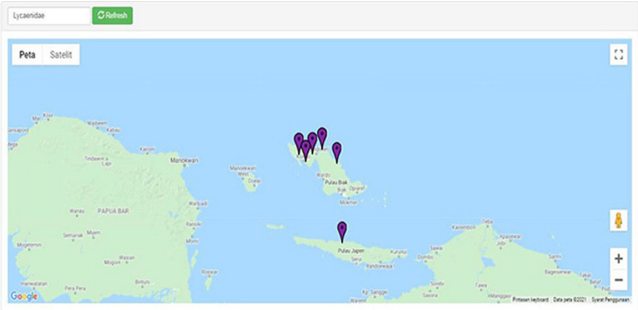

Fig. 13. The Distribution of Butterflies of the Lycaenidae Family

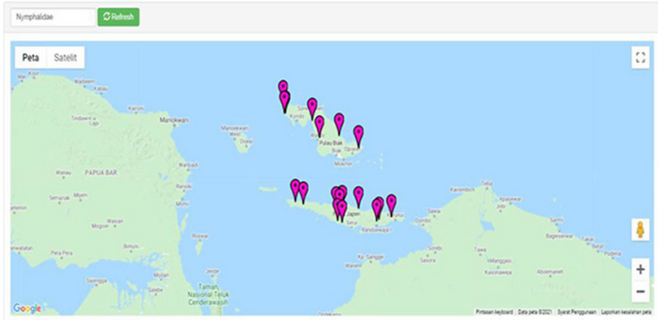

Fig. 14. The Distribution of Butterflies of the Nymphalidae Family

4 CONCLUSION

The Data Mining Application for the Spread of the Endemic Butterfly Cenderawasih Bay, Papua Province, using the K-Means Clustering Method, has been successfully built, which is expected to meet the data needs of the Cenderawasih Bay endemic butterfly. The conclusions that can be drawn from this study are as follows 1) The application can determine clustering according to the classification of 4 regions, 2) The application presents the distribution of endemic butterfly species with a map display; 3) The map of the distribution of endemic butterflies is shown based on the entire family and each family; 4) The application also provides a search process by family.

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6 AUTHORS

Fegie Y. Wattimena, Faculty of Science & Technology, University of Ottow Geissler, Papua, Indonesia.

Abilliyo S. Mampioper, Faculty of Science & Technology, University of Ottow Geissler, Papua, Indonesia.

Reni Koibur, Faculty of Science & Technology, University of Ottow Geissler, Papua, Indonesia.

I. Nyoman G. A. Astawa, Electrical Engineering Major, Bali State Polytechnic, Bali, Indonesia.

Dony Novaliendry, Universitas Negeri Padang, Padang, Indonesia.

Noper Ardi, Department of Informatics Engineering, Politeknik Negeri Batam, Batam, Indonesia.

Nenny Mahyuddin, Universitas Negeri Padang, Padang, Indonesia.