Identification Pests and Diseases of the Borneo Black Sweet in Tropical Rainforest

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Abstract. The Borneo black sweet Coelogyne Pandurata is one of the mascots of flora in East Kalimantan Tropical Rainforest. This orchid species only grows on the Borneo. The uniqueness of The Borneo black orchid Coelogyne Pandurata, has a black tongue (labellum) with a few green and hairy stripes. This research is to develop an expert system for identifying pests and diseases of black orchid using Bayes theorem. In this research 4 pests disturbed black orchids, namely bare snail pests, caterpillars pests, grasshoppers pests, and ant pests. The diseases that attacked black orchids were obtained, namely brown spot disease, fusarium wilt disease, soft rot disease, and root rot disease. The result of the calculation of the Bayes Theorem based on 5 symptoms chosen by the user that black orchid has a 40% chance of experiencing root rot disease.

1. Introduction

The tropical rainforests are part of the world's diverse ecosystems. Tropical rainforests also home to the world's richest diversity of flora and fauna species. Indonesia is one of the countries has the largest tropical rainforest and a variety of orchid species [1] [2] [3] [4]. Almost 30,000 species of natural orchids are scattered around the world, especially in tropical rainforests. Of that amount, 5,000 species of which come from Indonesia. Indonesia is a country that has many natural orchid species. One of the natural orchids which is a trademark of Indonesia is the black orchid (Coelogyne pandurata) [5] [6] [7] [8]. The Borneo black sweet Coelogyne pandurata has the local name is Kersik Luai. This orchid species only grows on the Borneo. Coelogyne pandurata is an epiphytic orchid, which attaches to other plants but does no harm [5] [9]. In the world there are 190 species of black orchids and 60 species are in Borneo. Black orchid is one of the mascots of flora in East Kalimantan. Although black orchids are synonymous with Kalimantan, this type of orchid is not only in the wild forests of Borneo, but The Malay Peninsula also grows wild in Sumatera and Papua. The uniqueness of Borneo black Orchid has a black tongue (labellum) with a few green and hairy stripes, the leaves and the crown are light green, not all black like the black orchids that grow in Papua [9]. Orchid flowers are scarce plants, so the government of the Republic of Indonesia makes special regulations to protect orchids. Based on the Government Regulation of the Republic of Indonesia Number 7 of 1999 concerning Preservation of Plant and Animal Species issued on January 27, 1999, signed by the President of the Republic of Indonesia Bacharuddin Jusuf Habibie stated that there are 29 rare orchid species including the black orchid (Coelogyne pandurata) that are protected by their existence [10].
The black orchid plant is an endemic orchid whose natural habitat is in the trees of the Borneo tropical rainforest. Black orchids as part of biodiversity need to be preserved. The orchids are very vulnerable to various pests. The types of orchids have been widely cultivated, making the disease difficult to identify. Symptoms of pest attack on orchids depend on the variety. If it is too late to identify pests and diseases of orchid plants, it will fail orchid cultivation [11]. In the effort of black orchid plant information literacy, a digital literacy information media is needed as a knowledge base that utilizes information and communication technology in developing expert systems which are a subsystem of artificial intelligence [12] [13] [14] [15] [16]. This research develops an expert system to identify pests and black orchid’s diseases as a support for the conservation of biodiversity in the East Kalimantan tropical rainforests.

2. Research Methodology

2.1. Expert System

Expert system is a part of artificial intelligence, where the system is based on the knowledge of an expert. Expert System is a system that to adopt the knowledge of human expert into a computer, so that the computer can complete a job as is usually done by experts. A computer-based expert system using facts, knowledge, and reasoning techniques to find the solutions that is usually only solved by experts in the field. [17] [18] [19].

The two main components of the expert system are knowledgebase and inference engine. The knowledgebase contains the knowledge and the inference engine that presents the results [19]. This expert system using the Bayes theorem will later be able to help collectors or black orchid lovers in identifying diseases or pests that attack their black orchid plants, so that they are properly treated, and can support the cultivation of black orchids.

2.2. Bayes Theorem

Bayes’ theorem is applied to a statistical diagnosis related to the probability and likelihood of diseases and symptoms. Bayes probability is one way to overcome uncertainty. Bayes' theorem is a method for solving the uncertainty problem. This method is very helpful in calculating a probability with a formula that is simpler than other methods. Bayes' Theorem also called Bayes' Formula, Bayes’ Rule, named after the 18th Century British clergyman and mathematician, Thomas Bayes. [20].

Several theories have been found to solve uncertainty, one of which is the Bayesian Probability. Bayes probability indicates the probability that something will happen or not. Utilization of the Bayes theorem is widely used in various applications including expert systems. This method is very helpful for system developers in calculating the probability value to determine the probability of an event. The probability of Bayes can be seen in the equation (1) [20].

$$P(H | E) = \frac{P(E | H) P(H)}{P(E)}$$  \hspace{1cm} (1)

With the following information:

\[P(H|E) = \text{Hypothesis probability based on Evidence} .\]
\[P(E|H) = \text{Evidence probability based on hypothesis} .\]
\[P(H) = \text{Hypothesis probability} .\]
\[P(E) = \text{Evidence probability} .\]

In general Bayes theorem with E evidence and hypothesis H can be seen in the equation (2).

$$P(H_i | E) = \frac{(E|H_i) P(H_i)}{ \sum_{i} (E|H_i) P(H_i)}$$  \hspace{1cm} (2)

With the following information:

\[P(H_i|E) = \text{Hypothesis probability based on Evidence} .\]
\[P(E|H_i) = \text{Evidence probability based on Hypothesis } H_i .\]
\[P(H_i) = \text{Hypothesis probability } H_i \text{ without any Evidence} .\]
2.3. Black Orchid

Black orchid is not only in the wild forests of Borneo, but the Malay Peninsula also grows wild in Sumatera and Papua. The uniqueness of the Borneo black orchid *Coelogyne pandurata* has a black tongue (labellum) with a few green and hairy stripes, the leaves and the crown are light green, not all black like the black orchids that grow in Papua [21] [10]. Black orchids have pointed petals reaching 5 cm in length. The flowers are quite fragrant and usually bloom from March to June. The black orchid plant is an endemic orchid whose natural habitat is in the trees of the Borneo tropical rainforest. Black orchids as part of biodiversity need to be preserved. Diseases and pests in plants are constraints when cultivating plants that can affect the growth of plant development. In addition, it will reduce productivity in plants in the form of plants that die quickly, flowers do not bloom, and so on [21]. Figure 1 about the Borneo black orchid.

![Figure 1. The Borneo Black Orchid](image)

2.4. Pests and Disease of Black Orchid

Pests and diseases in plants are one of the obstacles when cultivating plants, which can affect the growth and development of plants. Pests are one of the pests of plant pests which are important factors that must be considered in black orchid cultivation [10]. The difference between a pest and a disease is the damage it causes. Pests cause physical damage such as friction, puncture and others. Disease causes physiological disturbances in plants. Knowledge about pests and diseases of black orchids is obtaining from black orchid experts from the Food Crops and Horticulture Service, UPTD Agrotourism B3I. This study, there were 4 pests and 4 diseases in black orchids. Pests of black orchids are bare snail pest, caterpillar, Grasshopper Pest, and Ant pest. There are 4 diseases of black orchid are Brown Spots disease, *Fusarium* wilt disease, soft rot disease, and Root rot disease. The condition of pests and diseases of black orchid plants are shown in TABLE II.

2.5. Knowledge Base

The knowledgebase describes the rules to identify. The more symptoms that occur, the greater the occurrence so that the disease or pest detected is more accurate [19]. The Symptoms are shown in the TABLE I. Pests and diseases of Black Orchids are showing in TABLE II. The Bayes probability show in TABLE III.

| Code | Symptoms               | Value |
|------|------------------------|-------|
| G01  | Attack on young leaves | 0.73  |
| G02  | Holes and irregular leaves | 0.86 |
| Code | Symptoms                                      | Value |
|------|----------------------------------------------|-------|
| G03  | Attack on old leaves                         | 0.72  |
| G04  | Slimy and dirty leaves                       | 0.88  |
| G05  | Plants grow irregularly                       | 0.58  |
| G06  | Holes and irregular flowers                  | 0.67  |
| G07  | Hole in the middle of the stem and not visible from the outside | 0.67 |
| G08  | Wilted Leaves or Wilted plants               | 0.77  |
| G09  | Curly leaves or Wrinkled leaves              | 0.79  |
| G10  | The roots of plants will dry out              | 0.63  |
| G11  | Leaves rot or will rot                       | 0.78  |
| G12  | Roots inside and outside are damaged         | 0.59  |
| G13  | Plants or leaf surfaces have blackish spots  | 0.66  |
| G14  | Plants or leaf surfaces have brownish spots  | 0.79  |
| G15  | Yellowing Leaves or Yellowing Plants         | 0.62  |
| G16  | wound root                                   | 0.83  |
| G17  | Leaves blackened and softened                | 0.78  |
| G18  | Leaves fall out                              | 0.68  |
| G19  | Bad smell                                    | 0.82  |
| G20  | The roots will rot                           | 0.74  |
| G21  | The stem is thinning and bent                 | 0.72  |

**TABLE II. CONDITIONS OF DISEASE AND PEST**

| Code | Disease and Pest Conditions | Probability |
|------|-----------------------------|-------------|
| PH01 | Bare snail Pest             | 0.29        |
| PH02 | Caterpillar Pest            | 0.35        |
| PH03 | Grasshopper Pest            | 0.3         |
| PH04 | Ants Pest                   | 0.24        |
| PH05 | Brown Spots disease         | 0.21        |
| PH06 | *Fusarium* wilt disease     | 0.23        |
| PH07 | Soft rot disease            | 0.22        |
| PH08 | Root rot disease            | 0.21        |

**TABLE III. BAYES PROBABILITY**

| Bayes probability | Bayes Theorem     |
|-------------------|-------------------|
| 0 to 0.2          | Few Possibility   |
| 0.3 to 0.4        | Maybe             |
| 0.5 to 0.6        | Probably          |
| 0.7 to 0.8        | Sure              |
| 0.9 to 1          | Absolute          |

Rule base determination for the pests and diseases of black orchids are:
Rule 1: IF G01 AND G02 AND G03 AND G04 THEN PH01
Rule 2: IF G01 AND G02 AND G03 AND G06 THEN PH02
Rule 3: IF G01 AND G02 AND G05 AND G07 THEN PH03
Rule 4: IF G08 AND G09 AND G10 AND G12 THEN PH04
Rule 5: IF G08 AND G09 AND G13 AND G14 THEN PH05
Rule 6: IF G08 AND G09 AND G15 AND G16 THEN PH06
Rule 7: IF G08 AND G11 AND G17 AND G19 THEN PH07
Rule 8: IF G08 AND G18 AND G20 AND G21 THEN PH08

The treatment solutions given to deal with the problem of symptoms in the black orchid plants chosen by the user can be seen in TABLE IV.

| Code | Treatment Solutions |
|------|---------------------|
| PH01 | In small amounts just take or kill. |
|      | If a lot needs to use Insecticide or with Prusi Powder. |
|      | If the number of caterpillars (2-5) can be killed by hand. |
|      | If many can use systemic insecticides. |
| PH02 | Plants that have been attacked should be separated from plants that are still healthy. |
|      | Spray insecticides that contact toxic or systematic. |
| PH03 | If a small amount can be destroyed or killed immediately. |
| PH04 | The pot is submerged in water & creates a clean environment around the shelf or the pot should be hung. |
|      | Very difficult to cure at the beginning of the attack. |
| PH05 | In severe attacks, there is no other way except to destroy all affected orchid sprouts. |
|      | The affected part is removed and the former is sprayed with Fungicide (Benlate). |
|      | The plant is immediately transferred to a new, fresh and clean plant medium. |
| PH06 | Try to have a smooth flow of air around the plant. |
|      | Garden equipment must be sterile parts that are cut and thrown away. |
|      | Spray Physan20. |
| PH07 | Plant pots are sprayed with 4% Formalin. |
|      | All diseased parts of the plant are cut and thrown away. |
| PH08 | The scars are sprayed with Fungicide (Benlate). |

3. Result and Discussion

This section is about implementing an expert system to identify pests and diseases of black orchids and explains the calculation of the Bayes Theorem generated by the system.

3.1. Calculation of Bayes Theorem

For the example, application will diagnose a user’s black orchid with symptoms, namely: attack on young leaves (G01), attach on old leaves (G03), the roots of plants will dry out (G10), leaves fall out (G18) and The stem is thinning and bent (G21). Hypothesis conditions will be calculated based on the evidence: H1 Bare snail pets, H2 the caterpillar’s pests, H3 grasshopper pests, and H8 root rot using Bayes Theorem.

Probability of Pests and diseases:

\[
\begin{align*}
P(H1) &= 0.29 \\
P(H2) &= 0.35 \\
P(H3) &= 0.3 \\
P(H4) &= 0.24 \\
P(H5) &= 0.21, \\
P(H6) &= 0.23 \\
P(H7) &= 0.22 \\
P(H8) &= 0.21 \\
\end{align*}
\]

Value of the symptoms:

\[
\begin{align*}
G01 &= 0.73 \\
G03 &= 0.72 \\
G10 &= 0.63 \\
G18 &= 0.68 \\
G21 &= 0.72 \\
\end{align*}
\]
Phase 1: Calculation of the probability of Evidence base on conditions.

\[
\sum_{k=1}^{n} P(E|H_k) \cdot P(H_k) = P(E|H_1) \cdot P(H_1) + P(E|H_2) \cdot P(H_2) + P(E|H_3) \cdot P(H_3)
\]

\[
= (0.70 \times 0.29) + (0.65 \times 0.35) + (0.73 \times 0.3) = 0.6495
\]

Phase 2: determine the hypothesis Hi based on evidence.
The bare snail pests probability based on evidence of attach young leaves:

\[
P(H|E) = \sum_{k=1}^{n} P(E|H_k) \cdot P(H_k) = 0.73 \times 0.29 = 0.3259
\]

Phase 3: determine the Probability of evidence base on Hypothesis

\[
P(E3|H1) = (0.72 \times 0.29) + (0.72 \times 0.35) = 0.4258.
\]

The probability of bare snail pests based on evidence G03 are:

\[
P(Hi|E) = \frac{0.72 \times 0.29}{0.4258} = 0.4903
\]

Phase 4: determine the Bayes Universal value

The Bayes of Bare snail pests:

\[
\sum_{E_n}^{E} Bayes = 0.5159 + 0.4903 = 0.8152
\]

Do the calculations phase 1, 2, 3, and 4 for caterpillar pest too. In the condition of caterpillar pests, the symptoms are G01, G02, G03, and G06. The symptoms that occur are G01 and G03.

Phase 1: The calculation of caterpillar pest conditions based on evidence is:

\[
\sum_{k=1}^{n} P(E|H_k) \cdot P(H_k) = (0.72 \times 0.29) + (0.65 \times 0.35) = 0.6495
\]

Probability of caterpillar based on evidence of attach on young leaves (G01) are:

\[
P(H|E) = \frac{(0.73 \times 0.35)}{0.6495} = 0.3933
\]

Probability of caterpillar based on Evidence Attach on old leaves:

\[
\sum_{k=1}^{n} P(E|H_k) \cdot P(H_k) = (0.72 \times 0.29) + (0.62 \times 0.35) = 0.2088
\]

Probability of Hypothesis for G03:

\[
P(H02|G03) = \frac{0.72 \times 0.35}{0.2088} = 0.5918
\]

The Bayes of caterpillar pests:

\[
\sum_{E_n}^{E} Bayes = 0.3933 + 0.5918 = 0.9851
\]

Phase 1, 2, 3 and 4 for all evidence and all conditions, and so on until all evidence is calculated.
The Bayes of Grasshopper pests: Bayes3 = 0.3371
The Bayes of Ant pests: Bayes4 = 1
The Bayes root rot disease: Bayes5 = 2

Phase 5: Determine all universal value.
After all the hypotheses of the conditions are known, determine universal value by adding up all the Bayes value.

Universal value = Bayes 1 + Bayes 2 + Bayes 3 + Bayes 4 + Bayes 5
Universal value = 0.8162 + 0.9851 + 0.3371 + 1 + 2 = 5.1384

Phase 6: Determine diagnostic Bayes.
The Bayes value is obtained, then calculate the diagnostic value by means of each h Bayes probability is divided by the universal value 5.1384 that has been obtained.
The diagnostic Bayes of Bare snail:

\[
P(\text{Hi}|E) = \frac{0.8162}{5.1384} = 0.16
\]

The diagnostic Bayes for all conditions shown in TABLE V.

| Code | Conditions          | Probability of Bayes | Universal Value | Diagnostic Bayes |
|------|---------------------|----------------------|-----------------|------------------|
| PH01 | Bare snail pest     | 0.8162               | 5.1384          | 0.16             |
| PH02 | Caterpillar pest    | 0.9851               | 5.1384          | 0.19             |
| PH03 | Grasshopper pest    | 0.3371               | 5.1384          | 0.07             |
| PH04 | Ants pest           | 1                    | 5.1384          | 0.2              |
| PH08 | Root Rot disease    | 2                    | 5.1384          | **0.40**         |

In TABLE V it can be seen that the largest results is 0.40 in PH08 Root Rot Disease. In TABLE III, it can be seen that 0.40 is a condition of “MAYBE” in Bayes Theorem. So it means this black orchid plant has root rot disease 40%.

3.2. System Implementation

This section is about expert system on pests, diseases, and black orchid cultivation. Figure 2 is the homepage system view.
The consultation result shows the symptom data selected by the user, pests, disease, the percentage of diagnoses, and treatment solutions for black orchids, as seen in Figure 3.

Detail of the results of the consultation can be seen in Figure 4.

4. Conclusion
In this research, there were 4 pests: bare snails pests, caterpillars pests, grasshoppers pests, ant pests, and also 4 diseases that attacked black orchids, namely brown spot disease, Fusarium wilt disease, soft rot disease, and root rot disease. The application of Bayes Theorem is that black orchid plant has a 40%
chance of experiencing root rot disease. The treatment solution for the root rot disease is all diseased parts of the plant are cut and thrown away, and the scars are sprayed with Fungicide (*Benlate*).

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