Distribution of the critically endangered javan blue-banded kingfisher *Alcedo euryzona* along the Welo River flow in the Petungkriyono forest

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Abstract. This research was aimed to determine the ecological factors that can affect the distribution of *Alcedo euryzona* and its relationship with the quantification of human anthropogenic activities in the vicinity. The research was conducted using the point count method with 7 observation points along the Welo River (±5,096 km). Based on the analysis, the distribution pattern of *Alcedo euryzona* is uniformly based on Morisita’s index with a value of \( l_p < 0 (-0.033) \). Whereas the relationship between the existence of species and anthropogenic activity based on hypothesis test in binary logistic analysis partially has no significant effect with a value > 0.05 (0.999). The ecological factors that influence the existence of the species include river shoulders, temperature, and altitude.

Keywords: Distribution, *Alcedo euryzona*, anthropogenic activity.

1. Introduction

The critically endangered javan blue-banded kingfisher (*Alcedo euryzona*) is one of the endemic species of Java, where its population is estimated at only 50-249 adult individuals. Since 1930, there were only a few records of the species: two reports of two individuals at Mount Halimun Salak National Park in June 2009 and further observations by Coolemen in the same area in August 2014 [1]. Recently, the species was discovered in Petungkriyono forest, Pekalongan at 500-600 MSL in October and November 2018 [2]. In addition, the species was also recorded in the same area in July 2019 [3].

Petungkriyono forest is a primary forest characterized by lowland to mountainous tropical forest vegetation types. Its biodiversity is relatively protected and strongly supports the presence of wild animals. That is evidenced by the many research results that show the existence of a diversity of animals and plants in the region such as Javan Gibbon and Javan Fuscous Langur which are endemic Primates [4]. And also based on a study conducted by Epilurahman [5], was found an endemic Amphibi such as Javan Torrent Frog, Asian Horned Frog, Javan Flying Frog, and Java Forest Skink. Meanwhile, epiphytic ferns from the Aspleniaceae, Davalliaaceae, Hymenophyllaceae, Lycopodiaceae, Oleandraceae, Polipodiaceae and Pteridaceae families have been discovered [6]. The forest is also one of the famous water tourism destinations in Pekalongan, where many local and foreign tourists visit the Petungkriyono forest to enjoy its natural beauty.

This study was motivated by the lack of research on the Javan Blue-banded Kingfisher after its first discovery in Petungkriyono forest, Pekalongan. In addition, information on the ecological factors that
support the distribution of this species has not been studied before. Therefore, the purpose of this study was to determine the various environmental factors that influence the distribution of *Alcedo euryzona* (Figure 1) and its relationship to the quantification of human anthropogenic activity along the Welo River.

Figure 1. *Alcedo euryzona*, male

**2. Study Sites and Method**

**2.1 Time and Place**

This study was conducted along the Welo River (±5.096 km) that connects Kayupuring Village and Mesoyi Village in Petungkriyono forest, Pekalongan Regency, Central Java. This study used the point count method with an exploratory approach. Sampling was carried out in the morning and evening, 05.30 - 09.00 a.m and 02.00 - 05.00 p.m.

**2.2 Tools**

The tools used during the research were cameras, binoculars, watches, compasses, GPS, field sheets, hand counters, altimeters, measuring instruments, stationery, field guide books, Google Earth / QGIS (Quantum Geographic Information System) applications.

**2.3 Steps**

**2.3.1 Preliminary survey**

Initial observations were made by looking for potential species encounter points and human activities at Welo River, which flows through Kayupuring Village and Mesoyi Village. The observation point starts in Kayupuring Village and ended at Mesoyi Village. The distance between observation stations was measured using the Google Earth application. In addition, the administrative boundaries of the Petungkriyono sub-district were also mapped using the QGIS application to obtain an overview of the Petungkriyono area with the Welo River flowing through it. Furthermore, direct field observations were carried out to ensure the actual sampling area.

**2.3.2 Determine the station**

Observation points were carried out using the point count method on the banks of the Welo River which connects Kayupuring Village and Mesoyi Village. In addition, 7 observation points were selected by considering different habitat conditions. The observation point has a diameter (d) of 50 meters (Figure 2) and coordinates determined using GPS (F. According to Carlton [7], for very dense habitats where it is difficult to see birds (heavy forest/heavy bush), it is necessary to reduce the size of the circle where visibility is not more than 20 meters. But if not, then the viewing distance can be expanded up to 50 meters (Figure 3).
2.3.3 Data collections
Data was collected using field sheets which included observation time, moon phase, cloud coverage, weather conditions, and other ecological factors. In addition, data collection was carried out by recording the number of individuals, times encountered, and bird activities. The species was also documented using cameras for further observation activities.

2.3.4 Determination of ecological factors
To determine the ecological factors during observation, environmental variables such as temperature, altitude, habitat, and vegetation type were recorded at each observation station. Because the observation path is an area that is prone to tourist visits, the relevant variables used are following Francl and Schnell [8]:
1. Number of pedestrians who pass during the observation at each observation station
2. Number of passing motorcycles
3. Number of passing cars
4. Number of heavy vehicles (such as trucks, excavators, etc.) that pass
5. The number of buildings in each observation station
6. The number of water transportation that crosses the river during observations at each observation station
7. The distance between the center point of each observation station and the road
8. The distance between the center point of each observation station and the river

2.4 Data Analysis
Analysis of the correlation between primary data such as the individual mean of the Javan Blue-banded Kingfisher observed for each previously determined ecological factor. Correlation analysis using binary
logistic regression test. Then to find out the pattern of distribution, the species observed at each observation station were analyzed using the Morisita Index ($I_δ$) calculation [9] as follows:

\[ I_δ = \frac{n}{\left( \sum x^2 \sum x \right)} \]  
\[ \text{(1)} \]

\[ \text{Mu} = \left( \frac{x^2 \cdot 0.975 \cdot df^1 - n + \sum x^i}{(\sum x^i - 1)} \right) \]  
\[ \text{(2)} \]

\[ \text{Mc} = \left( \frac{x^2 \cdot 0.025 \cdot df^2 - n + \sum x}{(\sum x^i - 1)} \right) \]  
\[ \text{(3)} \]

Annotation:
- $I_δ$: Morisita index
- Mu: Uniform distribution pattern index
- Mc: Index of the aggregative distribution pattern
- $n$: Sample size
- $x_i$: Number of individuals in the $i^{th}$ sample unit

The decision rule for determining the shape of the distribution pattern of the observed organisms is as follows:

If the value of $I_δ \geq \text{Mc} \geq 1.0$, then $l_p$ is calculated using the equation:

\[ l_p = 0.5 + 0.5 \left( \frac{\delta - \text{Mc}}{n - \text{Mc}} \right) \]  
\[ \text{(4)} \]

If the value of $\text{Mc} > I_δ \geq 1.0$, then $l_p$ is calculated using the equation:

\[ l_p = 0.5 \left( \frac{\delta}{\text{Mc} - 1} \right) \]  
\[ \text{(5)} \]

If the value of $1.0 > I_δ > \text{Mu}$, then $l_p$ is calculated using the equation:

\[ l_p = 0.5 \left( \frac{\delta - 1}{\text{Mc} - 1} \right) \]  
\[ \text{(6)} \]

If the 95% confidence interval is the value $l_p$:
- $l_p < 0$, the distribution pattern is uniform
- $l_p = 0$, the distribution pattern is random
- $l_p > 0$, the distribution pattern is clumped

After the analysis results are known, the Javan Blue-banded Kingfisher is mapped by entering the coordinates of the species encounter into the Google Earth application to obtain a distribution map.

3. Results

3.1 Distribution of Alcedo euryzona

Table 1. Distribution pattern of 77 sample sizes at 95% confidence interval.

| Species          | n  | $l_p$ | Pattern   |
|------------------|----|-------|-----------|
| Alcedo euryzona  | 77 | -0.033| Uniform   |
3.2 Correlation of anthropogenic activity and habitat with species presence

Because the dependent variable is dichotomous (there is an encounter with a species and no encounter with a species), hypothesis testing is carried out using a logistic regression test. The stages in the test are as follows:

3.2.1 Regression model feasibility test
According to the Table 2, the model is acceptable since it can predict the value of the observation data with a value more than 0.05, which is 0.085. Therefore, this logistic regression model is suitable and feasible to use at a later stage.

| Step | Chi-square | df | Sig.  |
|------|------------|----|-------|
| 1    | 9.687      | 5  | .085  |

3.2.2 Overall model fit test
Based on the Table 3 and 4, it can be seen that the value of -2 Log-likelihood has decreased from step 0 to step 1, which is 42.144 to 39.250. With these results, the formed logistic regression model becomes better. Meanwhile, the Negelkerke R Square value is 0.088, which means the magnitude of the influence of the independent variable on the dependent variable is 8.8%. While 91.2% is explained by other variables outside the model.
Table 3. Value -2 LL constant.

| Iteration History | -2 Log likelihood | Coefficients Constant |
|-------------------|-------------------|-----------------------|
| Step 0            | -2.144            | 46.378                |
| 2                 | 42.354            | -2.281                |
| 3                 | 42.145            | -2.457                |
| 4                 | 42.144            | -2.471                |
| 5                 | 42.144            | -2.471                |

a. Constant is included in the model.
b. Initial -2 Log Likelihood: 42.144
c. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001.

Table 4. Value -2 LL with coefficient of determination.

| Model Summary | Step | -2 Log likelihood | Cox & Snell R Square | Nagelkerke R Square |
|---------------|------|-------------------|----------------------|---------------------|
|               | 1    | 39.250\(^a\)      | .037                 | .088                |

Based on the Table 5, the significance value of the model is known (p-value) > 0.05, which is 0.235. Therefore, it can be concluded that anthropogenic activities and the river shoulder (habitat) simultaneously have no significant effect on the existence of the species.

Table 5. Value Comparison -2 LL

| Omnibus Tests of Model Coefficients | Chi-square | df | Sig. |
|------------------------------------|------------|----|------|
| Step 1                             | 2.895      | 2  | .235 |
| Block                              | 2.895      | 2  | .235 |
| Model                              | 2.895      | 2  | .235 |

3.2.3 Regression equation

Based on the Table 6, the regression model can be formed as follows:

\[ Y = -4.359 + 0.126 + ( -18.983 ) \]

1. The constant obtained is -4.359, which means that if there is no anthropogenic activity and topography of the river shoulder, then there is no encounter with the species. Note: the constant is negative, so the probability is considered 0
2. The regression coefficient of the river shoulder variable is obtained at 0.126 (positive value) which means that every time there is a river shoulder, there will be a possibility of encounters with species
3. The regression coefficient for anthropogenic activity variables is -18.983 (negative value), which means that for every anthropogenic activity, there is no possibility of an encounter with a species.
| Variables in the Equation | B    | S.E. | Wald df | Sig. | Exp(B) |
|---------------------------|------|------|---------|------|--------|
| Step 1*                   |      |      |         |      |        |
| River                     | .126 | .158 | .639 1  | .424 | 1.134  |
| Anthropogenic             | -18.983 | 11513.858 | .000 1 | .999 | .000   |
| Constant                  | -4.359 | 2.705 | 2.59 1  | .107 | .013   |

a. Variable(s) entered on step 1: River, Anthropogenic.

Subsequently, the hypothesis test was conducted to determine the partial effect of each independent variable on the dependent variable using the t-test. Based on decision making, if the significance value is < 0.05 the hypothesis is accepted. Whereas, if the significance value is > 0.05 then the hypothesis is rejected. Based on table 4.6, the significance value for anthropogenic variables is > 0.05, which is 0.999. Therefore, partially anthropogenic activities do not significantly affect the existence of species. Meanwhile, the river shoulder variable (habitat) is > 0.05, which is 0.424. Therefore, partially the river shoulder (habitat) does not significantly affect the presence of species.

4 Discussion

Dispersal patterns are things that show the spatial relationship between members of a population in a habitat. This pattern is characteristic of a particular species depending on local environmental conditions and growth and behavioral characteristics. During sampling, encounters with species occurred up to six times (6 individuals) at observation posts 1, 2, 3, and 5, where it found at 381 MSL (post 5) as the lowest altitude and 513 MSL (post 1) as the highest. According to MacKinnon et al. [10], Alcedo euryzona lives near small rivers, in forested lowlands or hills to an altitude of 1,500 m (possibly preferring hilly areas). However, based on the number of encounters that occurred, it is known that the number of individuals found was three individuals. This is based on the identification of two persons, male and female, in posts 1 and 3. Meanwhile, because the encounter distance between posts 1, 2, and 3 is so great, one of the birds in post 5 is presumed to be a different individual. Based on the results, the distribution of Alcedo euryzona in the Petungkriyono forest showed a uniform distribution pattern. That can occur because of competition between the same individuals (positive competition) that encourages the same division of space [11]. And that is can also occur because environmental conditions are uniform throughout the area.

Uniform distribution happened because of the characteristics of the rocky river, which is the habitat of Alcedo euryzona. In addition, the cover area in the river flow also supports a uniform distribution because several types of plants are found at each observation point like Poaceae (bamboo), Fabaceae (kaliandra), Pteridophyta (ferns), and shrubs. With uniform cover area and rocky river flow in hilly areas, there will be competition between them. So as there is an even distribution of space and the formation of a uniform distribution pattern.

Meanwhile, to determine the effect of anthropogenic activities with the presence of the species at Petungkriyono forest, sampling was carried out by observing variables relevant to the observation location. The most appropriate variable based on the sampling location is counting the number of pedestrians who pass during the observation. It was conducted because the sampling location was steep and far from the road, so it was impossible to count the number of buildings or light and heavy vehicles. In addition, the stream current of the river also makes it impossible to calculate the distance between the observation points and the river.

Analysis of the relationship between human anthropogenic activities and the presence of species was carried out using binary logistic regression. Based on the regression equation and hypothesis test, it is known that the anthropogenic activity along the Welo river has no significant influence on the existence of species because only a few human activities are found at each observation point. In addition, anthropogenic activity at the observation site is also rare. Such as individual sand mining activities are
only found at 3 locations on the observation path. Meanwhile, the regression coefficient shows a negative value, which means that whenever there is an anthropogenic activity, there is no possibility of an encounter with the species.

Although only a few anthropogenic activities were found, such as small-scale sand mining carried out by individuals, in the short term it can cause river shoulder fragmentation such as the erosion of riverbanks and cause riverbed subsidence. And can also destroy ecosystems in the area around the river in the long term. In addition, the plastic waste found at each observation post can also cause a decrease in river water quality. According to Indrawati [12], inorganic waste in river waters causes an increase in heavy metal levels such as lead (Pb), arsenic (As), cadmium (Cd), mercury (Hg), nickel (Ni), calcium (Ca), and magnesium (Mg) which has an impact on human health. With the decline in river water quality, aquatic organisms such as fish and other small vertebrates will also decline. With the decreasing of fish and small vertebrates which are the diet of Alcedo euryzona, it is possible for a habitat shift to occur because they tend to look for new places that can provide the need to run their lives.

The results related to the relationship between the shoulder of the river and the presence of species indicate that partially the shoulder of the river (habitat) does not significantly affect it. However, the regression coefficient of the river shoulder shows a positive value where every time there is a shoulder of the river, there is a possibility of encounters with species. The results of hypothesis testing show that there is no effect because the sample data obtained are too homogeneous for testing. Therefore, it shows the form of a relationship that does not affect each other. Furthermore, if the test is at the population level, it may show a significant effect. Based on research conducted by Kajtoch and Piestrzyńska [13], environmental variables as the best natural components to explain the existence of species of Kingfisher are alluvial rivers, steep slopes, forests, and regulations. These four factors have 51% weight for the presence of Alcedo atthis.

Other environmental factors that can affect the existence of species include temperature. Based on the data obtained during sampling in the field, the average temperature at Petungkriyono forest in the morning in October – December was 20 °C and increased during the day. Based on research conducted by Kesler and Haig [14], microclimate factors including temperature, sun exposure, high winds, and humidity can influence the selection of nest sites in the wild and can affect the survival and reproductive success of Kingfisher. In addition, the Micronesia Kingfisher species can nest in the wild in a daily temperature range of 22.8 – 28.7 °C. Based on this, the temperature may also affect the presence of Alcedo euryzona at Petungkriyono forest.

5 Conclusion
The distribution pattern of Alcedo euryzona at Weloriver, Petungkriyono forest is uniform with an $I_p$ value of -0.033. And ecological factors that can affect the existence of Alcedo euryzona include altitude and temperature. The habitat (river shoulder) can also affect the presence of species if the analysis process at the population level and the type of data used is not homogeneous. Meanwhile, quantification of anthropogenic activity is known not to affect the presence of Alcedo euryzona at Petungkriyono forest because the observed anthropogenic activity is measly or rarely found.

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