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Short Communication: Orchid diversity in the riparian area of Samin River, Central Java, Indonesia

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Abstract. *Herdananta BY, Karina R, Khoirunnisa S, Nugraha GD, Setyawan AD. 2024. Short communication: Orchid diversity in the riparian area of Samin River, Central Java, Indonesia. Biodiversitas 25: 5046-5054.* Riparian area provides various ecosystem services, including the habitat of orchids. This research aimed to determine the diversity of orchid species along the riverbank of Samin River, Karanganyar-Sukoharjo Districts, Central Java, Indonesia. Data collection was conducted in three segments of the river: upstream (Blumbang and Gondosuli Villages), middle stream (Girilayu and Plosorejo Villages) and downstream (Kadokan Village). At each station, explorative method using cruising path with length of 1 km along the riverbank and width of 5-10 meters on both sides was used to document the presence of orchids. Data was analyzed to produce the Shannon-Wiener biodiversity index (H'), evenness index (E), and Margalef species richness index (R). This study recorded 19 species of orchids in which 13 species with 198 individuals were found in the upstream, four species with 154 individuals in the middle stream, and two species with 2 individuals in the downstream. Orchid species with the highest frequency was *Crepidium kobi*. There were 5 species of terrestrial orchids and 14 species of epiphytic orchids. For the epiphytic orchid, Zone 3 on the host tree was the zone with the largest number of species and individuals found. The upstream and middle stream had moderate diversity, while the downstream had low diversity. The three stations had different evenness categories in which quite evenly distributed in the upstream, less even in the middle stream and uneven in the downstream. All three stations had low richness index. The findings of this study suggest that the importance of maintaining riparian habitats to support the sustainability of biodiversity, especially orchid. Conservation efforts can help maintain the balance of ecosystems and biodiversity in this area. This study can be the basis for more effective conservation management in riparian areas.

Keywords: Biodiversity, Orchids, Orchidaceae, riparian, Samin River

INTRODUCTION

Riparian ecosystem is a unique ecosystem in the transitional zone between aquatic and land ecosystems along rivers, streams, lakes and other freshwater bodies. Riparian ecosystems play an immense ecological role, which benefit numerous organisms. Riparian ecosystem regulates hydrological cycle of a watershed, which is essential in soil and water conservation. Area along the riverbank provides important habitat for various flora and fauna, especially those living in aquatic and terrestrial ecosystems (Santos et al. 2020). The vegetation in the riparian zone also serves as carbon sink by sequestering and storing carbon in its biomass (Bental et al. 2017).

Riparian vegetation affects and is affected by the structure and characteristics of a river, such as size and shape, which vary among stream systems (Shahimi et al. 2019). The structure and function of a river can be disrupted due to the destruction of riparian vegetation. Many riparian ecosystems across the world are under severe threat due to various anthropogenic factors, such as agricultural activities, urbanization, changes in river flow, overexploitation, climate change, and pollution (Nobrega et al. 2020; Singh et al. 2021). It is anticipated that the loss and disturbances of riparian vegetation will have a detrimental effect on the stability and ecological function of riparian ecosystems (Singh et al. 2021). In particular, land use change is expected to affect primarily riparian flora and river water quality (Liu et al. 2019).

Due to its unique characteristics of continuously being wet and humid, riparian ecosystems serve as an important habitat for many flora species (Assal et al. 2021), including wild orchids. Orchids, as one of the most diverse plant groups, play an important role in the ecosystem, especially in riparian habitats (Pridgeon et al. 1999). Its presence helps increase biodiversity, creates additional habitat for various insects, birds and other small animals and helps reduce erosion on river banks. Native or wild orchids, to be different with cultivated and hybrid orchids, are orchid species that grow naturally in certain area (Heriansyah et al. 2014; Baiduri 2019).

In their natural habitat, environmental variables influencing the distribution, richness, and abundance of orchids include elevation, rainfall, temperature, humidity

and topography (Zhang et al. 2015; Djordjević et al. 2016, 2020). In general, there are two types of orchids based on their growing habitat, i.e., epiphytic and terrestrial. An epiphytic orchid has a habitat by sticking or hitchhiking on trees. The presence of trees in riparian ecosystem is important since they can serve as host plants for epiphytic orchids. The old, tall, large and branching trees allow the substrate to attach to the surface of the thick bark, providing water and nutrients for epiphytic orchids (Marsusi et al. 2001).

In Java, Indonesia, 731 species of native orchids have been identified, of which 231 species are considered endemics, and from 731 species, 295 species are in Central Java (Comber 1990). Then, still in Central Java Province, a total of 115 species from 54 genera of orchids were successfully identified by Kurniawan et al. (2021) in Mount Ungaran, including 78 species of epiphyte and 37 species of terrestrial orchids. Research by Romadlon et al. (2021) found *Paphiopedilum javanicum* as an endangered orchid categorized by appendix I in CITES in Mount Lawu. Additionally, there have been various research on the distribution and ecology of orchids in Central Java Province, for instance Yulia et al. (2011) with 19 species of orchids in Mount Lawu, Nugroho et al. (2018) with 18 species of orchids in Mount Merbabu, Farokhah et al. (2018) with 12 species orchids in Gebugan Nature Reserve, Zhara and Nugroho (2019) with 11 species orchids in Mount Lawu, and Purba and Chasani (2021) with 13 species in Mount Gajah. This shows that orchids are found in abundance in Central Java and it is necessary to continue to carry out new and in-depth research on this, especially in other areas where similar research has never been carried out. One place where this research has never been conducted is the Samin River.

Samin River is a stream belonging to the Bengawan Solo River, one of the most important river systems in Java, Indonesia. It flows through several districts in Central Java Province, including Karanganyar and Sukoharjo, before joining Bengawan Solo River (Muda 2018). Anecdotal evidence suggested the presence of native orchids along the riparian ecosystem of Samin River, although no further information is available regarding such orchids. Thus, botanical exploration and data inventory are important to reveal any taxonomical and ecological information as the baseline reference in developing orchid conservation strategies (Nasution et al. 2014). This research aimed to determine the diversity of orchid species in the Samin River, Central Java, Indonesia. It is important to understand the distribution and ecology of orchids, and the broader implications for river management and overall biodiversity conservation. By understanding this, appropriate steps can be taken to protect the river ecosystem and ensure its sustainability.

MATERIALS AND METHODS

Study area

This research was conducted in February-March 2024 in Samin River, Karanganyar-Sukoharjo Districts, Central Java, Indonesia (Figures 1 and 2). This river has a river length of 410.32 km (BPDAS Bengawan Solo 2017). For data collection, we established five stations along the river to represent three river segments of upstream, middle stream and downstream. The upstream was located in Gondosuli Village, Karanganyar (7°40'23.4732"S, 111°11'21.0768"E, 1600 m asl.) and Blumbang Village, Karanganyar (7°39'3.2076"S, 111°9'31.158''E, 1400 m asl.). These two places had high-density vegetation with more diverse plants compared to the middle and downstream. Then, the middle stream was located in Girilayu Village, Karanganyar (7°39'17.892"S, 111°4'55.6104"E, 600 m asl.) and Plosorejo Village, Mateseh Sub-district, Karanganyar at coordinates of 7°38'39.9732"S, 111°2' 59.0244"E, 350 m asl.). Both places had less dense vegetation compared to the upstream and rocky conditions. The downstream is located in Kadokan Village, Sukoharjo (7°35'58.4448"S, 110°49'59.4876"E, 80 m asl.). The downstream had the lowest vegetation with a more open riparian area and a wider river compared to the upstream and middle stream.

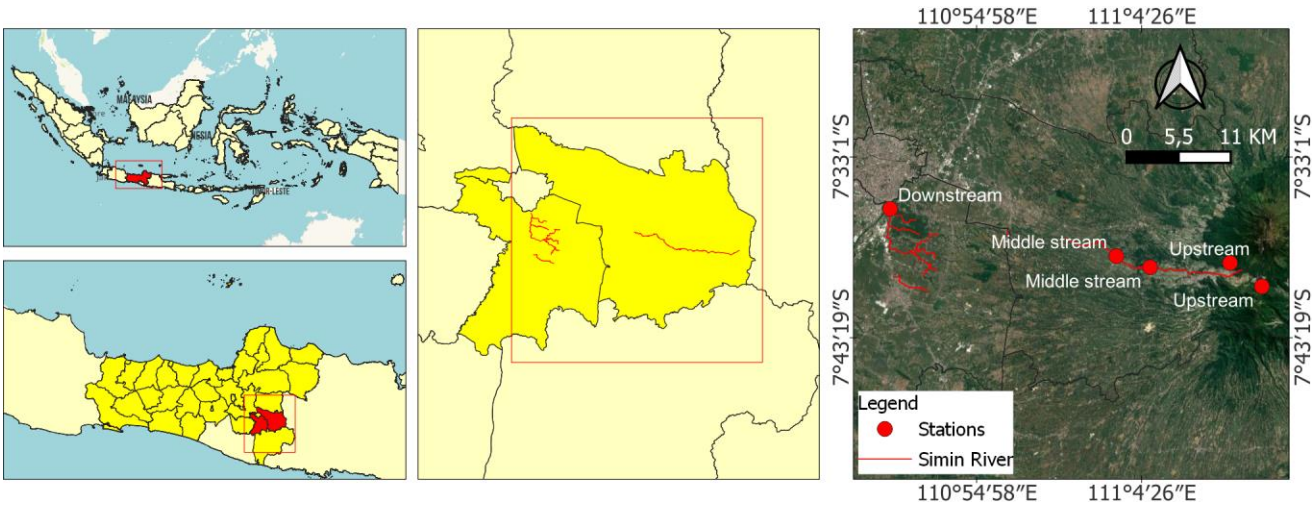

Figure 1. Map of the research location in Samin River, Karanganyar and Sukoharjo Districts, Central Java, Indonesia

Figure 2. Research locations in the Samin River, Karanganyar and Sukoharjo District, Central Java, Indonesia. A. Blumbang Village; B. Gondosuli Village; C. Girilayu Village; D. Plosorejo Village; E. Kadokan Village

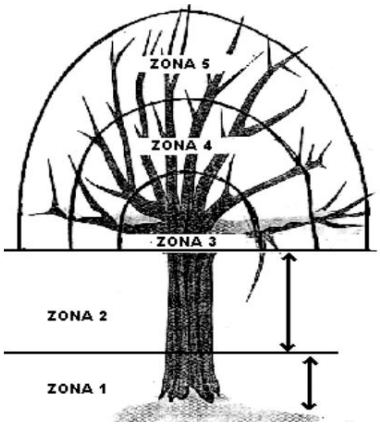

Figure 3. The zone of epiphytic orchid attached on tree. Zone 1: base of the tree; Zone 2: main trunk to main branching; Zone 3: basal branching; Zone 4: center of branching; Zone 5: outermost branching (Marsusi et al. 2001)

Data collection

This research used an explorative survey method by establishing cruising path along the river bank at each station with a length of 1 kilometer and width of 5-10 meters on the right and left of the river (Nugroho et al. 2018). The species and number of orchids along the path were counted and recorded. Abiotic factors, including air temperature, soil pH, air humidity, and soil humidity were measured. The dominant orchid species were also recorded at each station. Identification of orchids referred to Comber (1990). For epiphytic orchid, we also determined its position on the host which is divided into five zones as described in Figure 3.

Data analysis

Data on the number of species and the number of individuals of each species were calculated and analyzed to produce the Shannon-Wiener biodiversity index (H'), evenness index (E), and Margalef species richness index (R).

Shannon-Wiener Biodiversity Index (H')

Orchid diversity was analyzed using the Shannon-Wiener Index using the formula by Wheater et al. (2011):

$$H' = -\sum(Pi \ln Pi)$$

$$Pi = \frac{Ni}{N}$$

Where:
H' : Shannon-Wiener biodiversity index
P : Number of individuals of a species/total number of all species
Ni : Number of individuals of the i-th species
N : Total number of individuals
ln : Natural logarithm

The Shannon-Wiener was classified into three categories, i.e. low (H'<1.0), moderate (1.0≤H'≤3.0) and high (H'>3.0).

Evenness Index (E)

Evenness Index was calculated to determine the distribution of individuals of each species (Salami and Akinyele 2018) and calculated as follow (Pielou 1977):

$$E = \frac{H'}{\ln(S)}$$

Where:
E : Evenness index
H' : Shannon-Wiener biodiversity index
S : Total number of species found
ln : Natural logarithm

Evenness Index was classified into uneven (E = 0.00-0.25), less even (E = 0.26-0.50), quite even (E = 0.51-0.75), almost even (E = 0.76-0.95) and equally even (E = 0.96-1.00)

Margalef Species Richness Index (R)

The Margalef Species Richness Index of Margalef was calculated using the formula by Magurran (1998):

$$R = \frac{S-1}{\ln(N)}$$

Where:
R : Margalef species richness index
S : Total number of species found
N : Total number of individuals
ln : Natural logarithm

Margalef Species Richness Index was categorized into low (R<3.5), moderate (3.5<R<5) and high (R>5).

RESULTS AND DISCUSSION

Orchid species along Samin River

Based on the results of this study, a total of 19 orchid species were found, consisting of 14 species of epiphytic orchids, while the rest were terrestrial orchids (Table 1, Figure 4). The upstream part of the river, which included Blumbang and Gondosuli Villages, had the highest number of orchid species with 13 species and 198 individuals and followed by the middle stream at Girilayu and Plosorejo Villages with 4 species and 154 individuals. In the downstream at Kadokan Village, only 2 species were found with a total of 2 individuals. The upstream part of the river had high orchid diversity because the ecosystem condition was maintained that support the growth of orchids. In the middle stream, despite only 4 species, there were a relatively large number of individuals. The low diversity and abundance in the downstream are likely because the high disturbances due to the presence of residential areas and pollution of industrial waste. Low temperature, humidity, and high rainfall, especially in upstream areas, cause tree branches to become moist, so many epiphytic orchids are found (Barus et al. 2018).

The majority of orchid species were epiphytic habitats with 14 species compared to 5 species of terrestrial orchids. Epiphytic orchids have high diversity because they exploit the rich, three-dimensional canopy environment, which offers varied niches, better access to light, specialized pollinator interactions, and fewer disturbances (Zotz 2013). Terrestrial orchids, on the other hand, face limitations in altitude and soil-based habitats with more competition and fewer opportunities for niche specialization. The highest presence of orchids was found at an altitude of 1250-1650 meters above sea level and the lowest was at an altitude of 50-100 meters above sea level (Table 1). Altitude between 1,400-1,500 meters above sea level is considered as the most suitable habitat for terrestrial orchids, as revealed by Pasaribu et al. (2015) and Banurea et al. (2015). Apart from the altitude, the soil conditions at the research site also affected the presence of terrestrial orchid due to the presence of dry leaves and litter to obtain nutrients.

Orchid species with the highest frequency was *Crepidium kobi* (Table 1). The high abundance of *C. kobi* is likely due to a mutually beneficial symbiosis between orchid mycorrhiza and soil fungi. Research by McCormick (2018) found that mycorrhizal fungi can affect the distribution and abundance of mycorrhizal partners, affecting plant characteristics and populations, such as the frequency of occurrence or plant density, including orchids. Nugroho et al. (2018) also stated that mycorrhizal fungi can significantly affect terrestrial orchids compared to epiphytic orchids whose roots are difficult to symbiotically form mycorrhiza. Fungi from mycorrhizal take organic substances from the soil, which are then converted and transfered to orchids, in return orchids provide the results of their assimilation to the fungi (Sugiyarto et al. 2016).

Table 1. Orchid diversity in Samin River, Karanganyar-Sukoharjo Districts, Central Java, Indonesia

Scientific name	No. of individual	Station					Altitude (m asl)	Habitat	Tree zone
		Upstream		Middle stream		Downstream			
		B	GS	G	P	K			
Acriopsis lilifolia Reinw. ex Blume	21			√			690	E	3
Aerides odorata Lour	1					√	50-100	E	2
Appendicula alba Blume	23	√					1403	T	-
Arundina graminifolia (D.Don) Hochr.	38			√			658	T	-
Bulbophyllum angustifolium (Blume) Lindl.	3		√				1250-1650	E	2
Bulbophyllum flavescens (Blume) Lindl.	5		√				1250-1650	E	3
Bulbophyllum flavidiflorum Carr	8		√				1250-1650	E	2
Calanthe flava (Blume) C.Morren	1		√				1250-1650	T	-
Calanthe sp.	1	√					1531	E	4
Dendrobium crumenatum Sw.	65			√	√		389-690	E	3
Eria multifora (Blume) Lindl.	7		√				1250-1650	E	3
Gastrochilus sororius Schltr.	1		√				1250-1650	E	3
Coelogyne longifolia	6	√					1531	E	4
Crepidium kobi (J.J. Sm.) M.A.Clem. & D.L.Jones	84	√					1403	T	-
Pholidota carnea (Blume) Lindl.	26	√	√				1403-1354	E	3
Rhyncostilis retusa (L.) Blume	1					√	50-100	E	2
Spathoglottis plicata Blume	30	√		√			658-1354	T	-
Trichotosia annulata Blume	1	√					1531	E	3
Vanda tricolor Lindl.	5	√					1531	E	3

Notes: B: Blumbang Village, GS: Gondosuli Village, G: Girilayu Village, P: Plosorejo Village, K: Kadokan Village, T: Terrestrial, E: Epiphytic

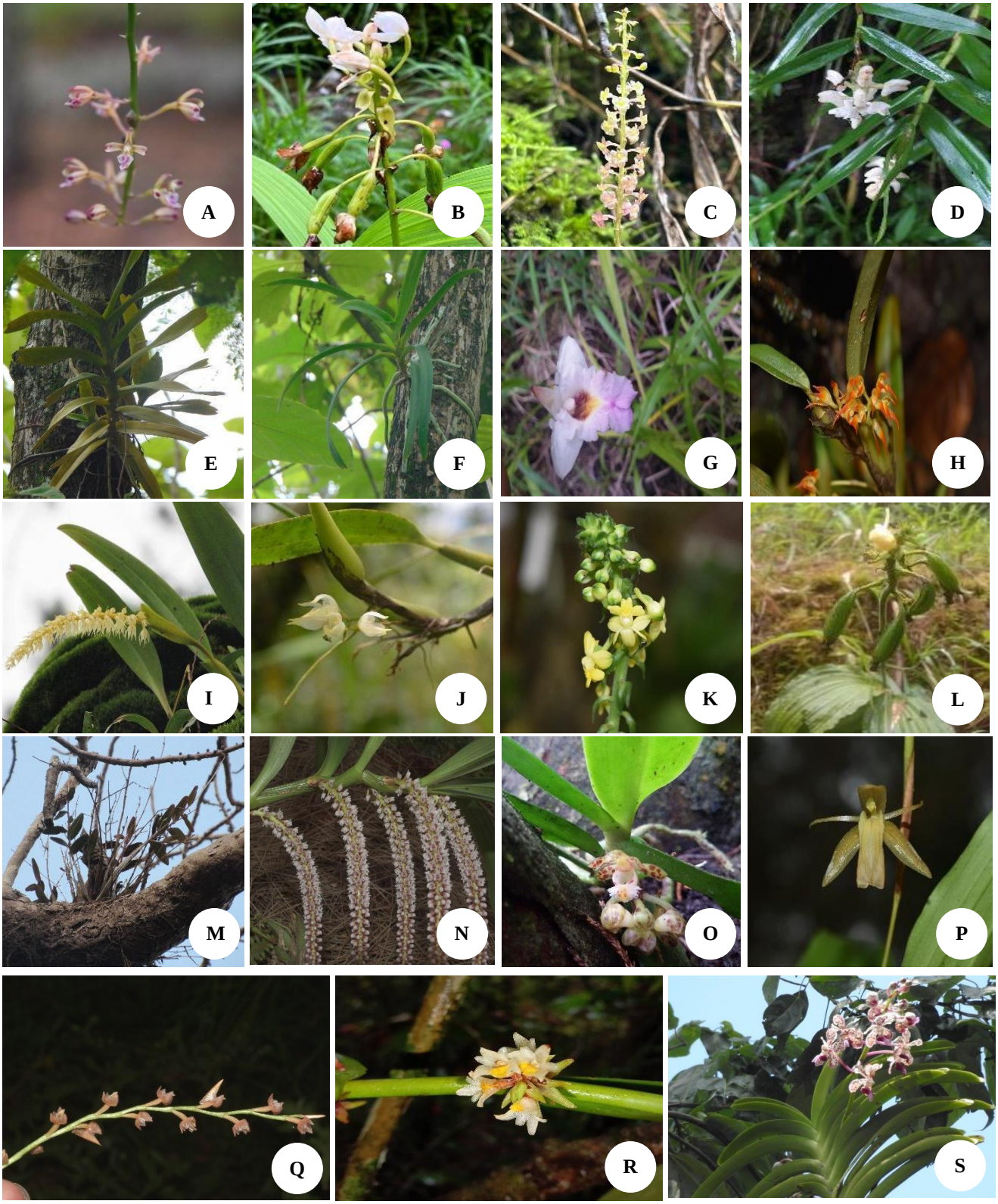

Figure 4. Orchid species in the riparian of Samin River, Central Java, Indonesia. A. *Acriopsis lilifolia*; B. *Spathoglottis plicata*; C. *Crepidium kobi*; D. *Appendicula alba*; E. *Aerides odorrata*; F. *Rhyncostilis retusa*; G. *Arundina graminifolia*; H. *Bulbophyllum angustifolium*; I. *Bulbophyllum flavescens*; J. *Bulbophyllum flavidiflorum*; K. *Calanthe flava*; L. *Calanthe* sp.; M. *Dendrobium crumenatum*; N. *Eria multifora*; O. *Gastrochilus sororius*; P. *Coelogyne longifolia*; Q. *Pholidota carnea*; R. *Trichotosia annulata*; S. *Vanda tricolor*

Ecological indices

Shannon-Wiener Diversity Index (H')

The upstream part of the Samin River, including Blumbang Village and Gondosuli Village, had a diversity index of 1.81, falling as moderate diversity, while the middle stream at Girilayu Village and Plosorejo Village was 1.30 (moderate) and the downstream at Kadokan Village was 0.69 (low). When all stations were combined, the diversity index was 2.23 (moderate) (Figure 5). The upstream area has a cool and humid environment that is suitable for orchids to live in. This is in line with the research by Ye et al. (2022), which showed that orchid diversity is influenced by altitude and temperature, such as in the Beipan River basin. Apart from that, the environment in the upstream area is more stable compared to the middle stream and downstream because it has not been disturbed by anthropogenic activities. Therefore, the upstream biodiversity index is higher than that in the middle stream and downstream. According to Putriningtias et al. (2019), species diversity is influenced by the type of habitat where they live, stable environment, productivity, competition, and nutrient availability. Other studies have also shown that higher orchid biodiversity is due to unique ecological conditions and limited anthropogenic impacts. Research by Suyundukov and Kildiyarova (2023) showed that upper river basins often have suitable microclimates that support a variety of orchid species, as seen in the Ural River basin, where orchids are found in less accessible area.

Evenness Index (E)

The upstream of the Samin River had an evenness index of 0.62 (quite even), while the middle part was 0.44 (less even) and the downstream was 0.24 (uneven). If all stations are combined, the evenness index was 0.76 (quite even) (Figure 5). Evenness Index was calculated to determine the distribution of individuals of each species (Salami and Akinyele 2018). The lower evenness index indicates the domination of one or a few species, with other species having a very small number of individuals. Low evenness often reflects ecological imbalance or dominance by a few species well-adapted to the environment (Rohman et al. 2023). Nuraini et al. (2020) stated that evenness index is directly proportional to the diversity index.

Margalef Species Richness Index (R)

The upstream of the Samin River had a species richness index value of 2.27 (low), while the middle stream was 0.60 (low) and the downstream was 1.44 (low). If all stations combined, the species richness index was 3.11 (low) (Figure 5). This index is a measure used in ecology to quantify the number of different species in a defined area or ecosystem. It is one of the simplest metrics of biodiversity (Magurran 2004). The species richness of an area depends on the healthy and suitability of its habitat or ecosystem. The richness index indicates that the increase in the number of species is inversely proportional to the number of individuals. According to Ismaini et al. (2015), the higher the number of species found, the greater the richness index.

Tree zone of epiphytic orchids

We found that epiphytic orchids in Samin River were distributed over tree zones of 2, 3 and 4 where four, eight and two orchid species were found, respectively (Figure 6). Orchids grow on varying tree zones to adjust to their surroundings and acquire the most possible air, light, and nutrients (Marsusi et al. 2001). The highest number of orchids were found in Zone 3, which is located in the lower third from the base of the branches to the main stem and has the smallest degree of slope. This zone allows for greater water and nutrient accumulation than the other zones. In terms of orchid growth, Zone 3 is more favorable compared to Zone 2 which has a slope of almost 90 degrees which makes it difficult for epiphytic orchids to attach. Apart from that, Zone 3 is also preferable compared to Zone 4 and 5, which are located at the end of the branch since they have a smaller size (Gunaga et al. 2024), and compared to Zone 1 since Zone 3 allows for greater exposure to sunlight and wind flow.

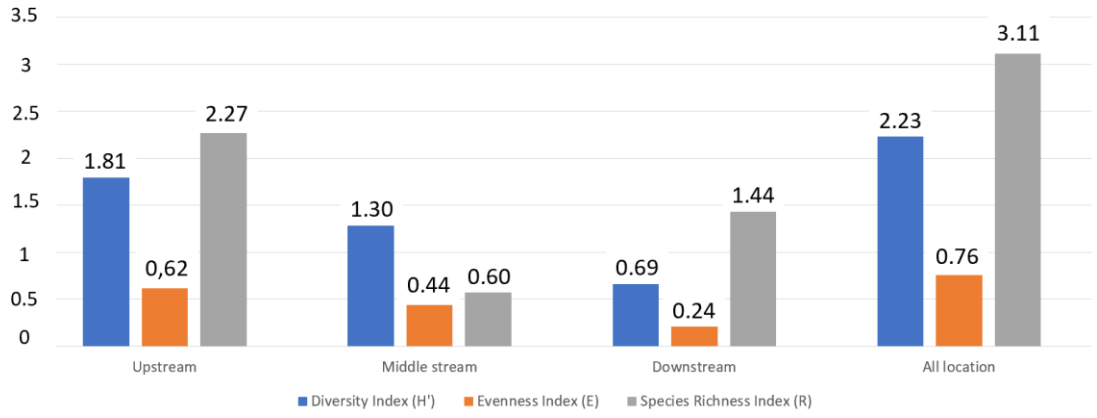

Figure 5. Comparison of ecological indices at each segment of Samin River, Karanganyar-Sukoharjo Districts, Central Java, Indonesia

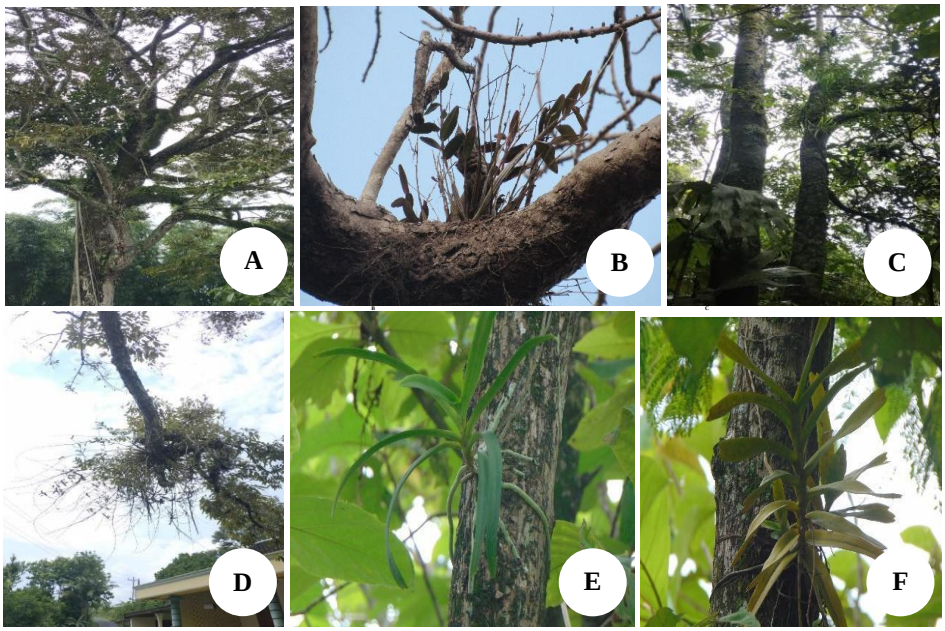

Figure 6. Epiphytic orchids in various zones of trees in Samin River, Karanganyar-Sukoharjo Districts, Central Java. A. Zone 3 and 4; B. Zone 3; C. Zone 3; D. Zone 3; E. Zone 2; F. Zone 2

Zone 3 has a better ability to store water and nutrients compared to other zones, which is very beneficial for epiphytic orchids. In addition, branches in Zone 3 tend to be flat, allowing for the decomposition of litter and dust and the collection of rainwater or morning dew. Epiphytic orchids prefer host trees with thick, rough, cracked outer bark, and umbrella-shaped crowns with normal branching, although the stems may be deformed due to wounds or breaks since these conditions will ease the orchids to attach compared to trees with smooth bark (Rina et al. 2023). Additionally, Nugroho et al. (2019) stated that Zone 3 is the zone where most orchids grow because it is more shaded by tree branches, its location is not too high so it is not exposed to direct sunlight and is quite exposed to the wind.

Abiotic factors

Abiotic parameters measured in this study included air temperature, air and soil humidity, and soil pH (Table 2). Temperature ranged from 22°C to 38.4°C on average, where the highest was at Kadokan Village with 38.4°C and the lowest was at Gondosuli Village with 22°C. Air humidity ranged from 67% to 90% where the highest was at Blumbang Village with 90% due to the presence of fog and the lowest was at Kadokan Village. Soil moisture ranged between 1.1 and 1.8, with the lowest being at Blumbang Village, Gondosuli Village, and Girilayu Village, while the highest was at Plosorejo Village and Kadokan Village. Soil pH was not significantly different, which only ranged from 6.9 (Plosorejo Village and Kadokan Village) to 7 (Blumbang Village, Gondosuli Village, and Girilayu Village).

This study revealed that orchids were abundant in riparian habitats with abiotic conditions suitable for their growth. This is in accordance with Besi et al. (2021) that riparian forests are an important habitat for orchid species, especially epiphytic plants, which prefer cooler microclimates with heavy airflow. Other research conducted by Cardoso (2014) and De Moraes et al. (2015) in riparian forests in Brazil found 11 and 16 orchid species, respectively. The diversity of orchid species is influenced by climatic conditions. Chandra et al. (2020) state that the temperature suitable for orchids ranges from 15-28°C. Based on Table 2, the temperature in the upstream to middle stream was within the range as mentioned by Indarto (2011), while the downstream had high temperature. Another influencing factor is humidity, where orchids generally prefer humidity of 60-80% (Tagentju et al. 2020). The best humidity for orchids is not too high at night and not too low during the day. Apart from temperature and humidity, Najikh et al. (2018) stated that light intensity could also affect orchid growth. The intensity of sunlight has an influence on the physiology of orchids for growth, both directly and indirectly. The intensity of light from the sun needed by orchids varies among species; if the intensity of sunlight obtained by orchids is lower or higher than their needs, it can also inhibit orchid growth.

The upstream area had a relatively moderate temperature (22-23.8°C) and high humidity almost all year round, making this area suitable for the growth of various orchids. The middle stream had a relatively moderate temperature with an average of 27°C and humidity within the criteria for orchid growth. This area has an altitude of 600 ± 700 meters above sea level with relatively neutral soil pH. Thus, several species were still found, although not as diverse as in the upstream. This is supported by the research of Sesar et al. (2020), who found many orchid populations at temperature of 24-28°C, air humidity 84-92.3%, soil temperature 24-28.3°C and soil pH 6.2-7.3. In the downstream area, due to the high temperature, only a few species were found in small numbers. This is because altitude influences the distribution and growth of orchids (Munandar et al. 2018).

Table 2. Abiotic factors at each research station in Samin River, Karanganyar-Sukoharjo Districts, Central Java, Indonesia

River segment	Villages	Est. of altitude (m asl.)	Air temperature (°C)	Humidity (%)		Soil pH
				Air	Soil	
Upstream	Gondosuli	1600	22	87	1.1	7
	Blumbang	1400	23.8	90	1.1	7
Middle stream	Girilayu	600	25	87	1.1	7
	Plosorejo	350	29	77	1.8	6.9
Downstream	Kadokan	80	38.4	67	1.8	6.9

In conclusion, there were 19 orchid species along the riparian ecosystem in Samin River, Karanganyar-Sukoharjo Districts, Central Java with varying distribution, diversity, evenness, and species richness across river segments. Orchid species with the highest frequency was *Crepidium kobi*. The upstream and middle stream had a diversity index in the moderate category, while downstream had a low diversity. The upstream had quite even distribution of orchid, and less even in the middle stream and uneven in the downstream. All three segments had a low richness index. The results of this study provide an important contribution to the understanding of biodiversity in riparian areas, especially in the context of orchid species distribution. These findings also underline the importance of maintaining riparian habitats to support the sustainability of orchid populations, especially in the upstream area which has the highest level of diversity. Conservation efforts focused on protecting natural habitats, sustainable ecosystem management, and regular monitoring of orchid populations can help maintain the balance of ecosystems and biodiversity in this area. Thus, this study can be the basis for more effective conservation management in riparian areas.

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