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Revealing herpetofauna diversity at Brantas River, East Java, Indonesia: Evidence of decreasing populations

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Abstract. *Rohman F, Priambodo B, Akhsani F, Rahayu SE, Wangkulangkul S, Kundariati M. 2022. Revealing herpetofauna diversity at Brantas River, East Java, Indonesia: Evidence of decreasing populations. Biodiversitas 23: 1475-1481.* Conservation planning is very important to preserve nature and ecosystems. Based on this, exploration and species inventory in nature need to be carried out. Group of animals that have an important role in the environment is herpetofauna. This study aims to reveal the abundance, evenness, and richness of herpetofauna in Brantas River's streams connection. This study uses the Visual Encounter Surveys (VES) sampling method at 8 points located in Blitar, Tulungagung, Malang, Mojokerto, Kediri, and Batu City, East Java, Indonesia. The results showed that the diversity index (H') $1 < 2, 3959 < 3$, with the criteria for the diversity index being moderate. The value of e is $0.74 > 0.6$, which means high species uniformity. Specific richness has a value of 4.53 which means in the moderate category. There were 12 species of amphibians and 14 reptile species. Five species are of low-risk status with decreasing population in nature and two species is of vulnerable status. Species in the declining category are *Odorrana hosii, Limnonectes microdiscus Wijayarana masonii, Leptobrachium hasseltii,* and *Philautus aurifasciatus.* Species in the vulnerable category are *Microhyla orientalis* and *Gonocephalus kuhlii.* Species in the declining category require attention from conservation efforts because their presence is important in various aspects of the ecosystem, such as the food chain, bioindicators, and natural enemies.

Keywords: Amphibians, Brantas river, community structure, conservation, reptile

INTRODUCTION

Global biodiversity has developed as a result of its insular nature and complex geological history (von Rintelen et al. 2017). Indonesia is one of the mega-biodiversity countries (UNEP WCMC 2014), which has Java Island, one of the biggest islands in Indonesia, considered of the terrestrial ecoregions on the planet. The wildlife biodiversity and ecosystem diversity in this region are abundant, including amphibian and reptile species. So many endemic animal species have been reported (Riyanto et al. 2015; Cahyadi and Arifin 2019). Each animal has its role in nature and giving a significant impact on the ecological setting, so do herpetofauna. It has a role as the bioindicator of environmental and climate change (Bickford et al. 2010).

Herpetofauna, which is ectothermic species, will be affected by climate changes. The increasing global temperatures cause abnormal and extreme rainfall cycles (Seneviratne et al. 2012). Herpetofauna populations and species could be wiped out by rising temperatures, reduced precipitation, and habitat loss (Hansen et al. 2001; Bickford et al. 2010). Furthermore, the reptiles and amphibians are the finest of the key bio-indicators for measuring the impact of climate change because their current distributions and ecological niches closely reflect temperature patterns (Bickford et al. 2010).

In contrast, due to the rapid changing of technology and human life being, natural distortion has been overcome in recent years. The increment in the human population and environmental change is the cause of major anthropogenic habitat loss and decline in biodiversity (Marchese 2015; Sutarno and Setyawan 2015). This rapid development also occurs on the Brantas River. Brantas is a river with a length of 320 kilometers and is a river that plays an important role for the people of East Java, especially in the Regencies/Cities of Malang, Blitar, Kediri, to Surabaya (Yetti et al. 2011). The Brantas River has been polluted physically, chemically, and biologically (Lusiana et al. 2020; Lusiana et al. 2020; Yetti et al. 2011) cause the overload of the human population and waste from residents' housing which cause the biodiversity degradation. Therefore, herpetofauna abundance, evenness, and diversity assessment are important to determine the conservation status and planning (Gardner 2001; Gojo Cruz et al. 2019; IUCN Red List Committee 2013; Kreft et al. 2004) due to its role as bioindicator.

Diversity information of animals can be considered as a basis for prioritization in the conservation strategy and focusing efforts on the most threatened species by environmental pressures (Gordon and Newton 2006; Torres-Miranda et al. 2011). In the long run, Indonesia has to find a balance between protectionism and sensible access to its national biodiversity to tackle global challenges in biodiversity conservation (von Rintelen et al. 2017).

Mainly because it is easy to quantify and interpret data, species richness (SR) has been the main focus of conservation studies (Davies and Cadotte 2011).

Several studies on herpetofauna species diversity in the south-east Asian region have already been completed, including works in the Philippines (Diesmos et al. 2015; Gojo-Cruz et al. 2019; Clores et al. 2021), Malaysia (Shahrudin et al. 2011; Munisamy et al. 2020; Onn and Ahmad 2021), Indo-china (Bain and Hurley 2011), and Indonesia (Noberio et al. 2015; Cahyadi and Arifin 2019; Dharma and Meitiyani 2019; Irwanto et al. 2019; Leo et al. 2020; Milto and Lukin 2020; Nurhayat et al. 2020; Amarasinghe et al. 2021; Riyanto and Rahmadi 2021). These past studies only focused on herpetofauna distribution and diversity in the Indonesian rainforest area. But, the study of herpetofauna biodiversity in the Brantas river, which is located in East Java Indonesia is still limited. This river is large and vital in the midst of Javanese society which we know that Java is the most populous island in Indonesia. Therefore, a study is needed to investigate the diversity of herpetofauna in the Brantas River area, East Java, Indonesia. Last but not least, given Java Island's rapid development and expanding human population, we see a need to create conservation programs for amphibians and reptiles, to increase local awareness and protect the populations. Such programs, however, are dependent on information about species distribution, abundance, and habitats. It is hoped that this study will be a first step in providing this urgently needed and critically important basic information.

MATERIALS AND METHODS

Study area

Herpetofauna exploratory studies were conducted in the tributaries of the Brantas River's streams connection located in Mojokerto, Tulungagung, Malang, Kediri, and Blitar, East Java, Indonesia. This study was conducted from February to July 2021, at 8 sites (for details, see Table 1). The sampling site map shows in Figure 1.

Table 1. Sampling sites on herpetofauna survey at Brantas River's streams connection, East Java Province, Indonesia. Specific sampling localities are followed by encompassing administrative district, and cities

Sampling site	Sampling localities	Coordinates	Habitat types
1	Sendang, Tulungagung	S 7°54'49.730644"; E 111°49'17.958984"	Fast riverbank, bamboo, tourist spot
2	Tunjungsari, Blitar	S 8°8'13.27397" ; E 112°10'36.27276"	Stream, spring, bamboo, taro garden
3	Sendang, Tulungagung	S 7°53'13.404579"; E 111°46'55.823364"	Stream, the banks of a fast-flowing river
4	Wlingi, Blitar	S 7°58'36.905594"; E 112°25'55.691528"	Stream, spring, tea garden
5	Lowokwaru, Malang	S 7°45'51.4"; E 112°31'27.0"	Stream and bamboo
6	Prajurit Kulon, Mojokerto	S 7° 28'27.19247"; E 112°24'51.9902"	Riverbank
7	Mojo, Kediri	S 7°51'53.53125"; E 111°51'7.95652"	Riverbank
8	Bumiaji, Batu	S 7°45'51.4"; E 112°31'27.0"	Stream, spring, tea plantation

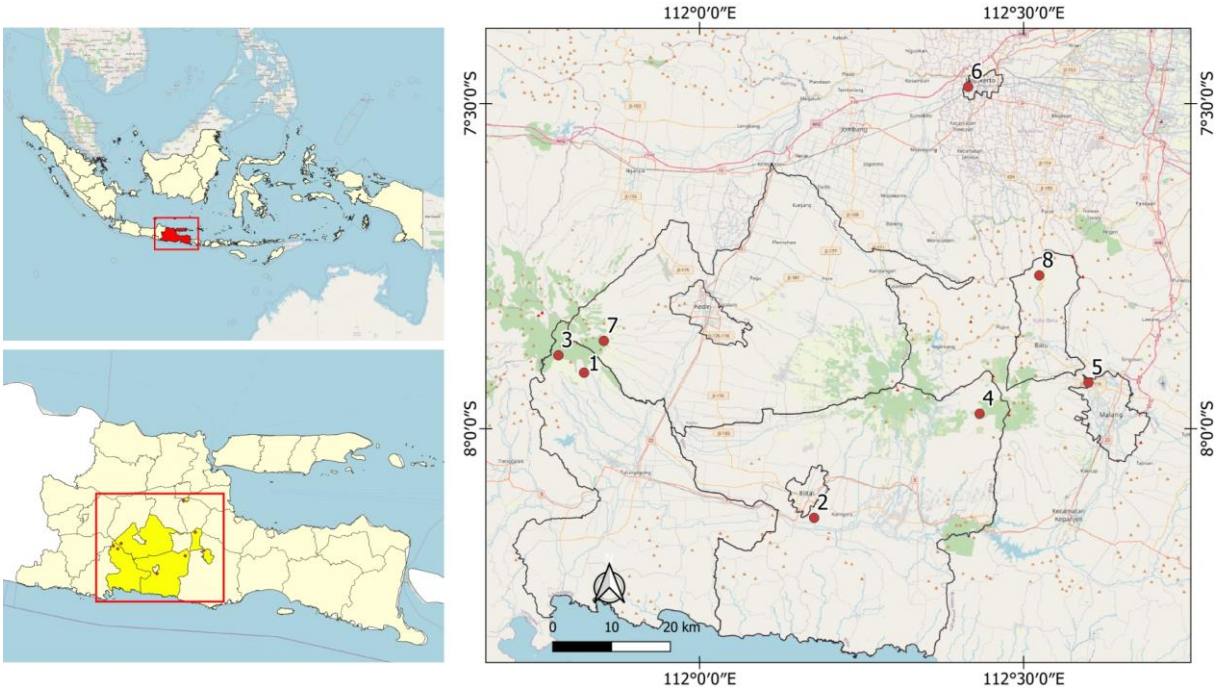

Figure 1. Sampling sites map in Brantas River, East Java, Indonesia (see Table 1 for sequential numbers)

Procedures

This study was conducted through Visual Encounter Surveys (VES), opportunistic searching of the herpetofauna at 8 sites. We conduct this method by seven people in the Brantas River's stream connection which ranging approximately 3-5 meters width. Each sampling site was sampled once or two times. The exploration ranging around 3-4 km with a time span of 4 hours.

The taxa needed further taxonomic identification were collected by hand, identified using morphological features, and pictures were taken, and the animal was then released back to nature. Taxonomy guides in this study were Uetz et al. (2021) for reptiles and Frost (2021) for amphibians. The national conservation status of each species was checked based on international conservation status according to The International Union for Conservation of Nature's (IUCN) Red List Committee (2013) and Appendices of Convention on International Trades on Endangered Species of Wild Flora and Fauna (CITES) 2021.

Data analysis

The data analysis used is using the calculation of the Shannon-Wiener diversity index with the formula (H' = ∑Pi ln Pi) with the Wilhm and Doris (1986) for the category guidelines, *evenness* (E) with the formula (E = H'/ln s) with Krebs (1985) for the category guidelines, richness with the formula (R = (s-1)/ln N) with the Margalef index for the guidelines.

RESULTS AND DISCUSSION

Herpetofauna that has been explored from eight sampling sites are then analyzed for diversity, evenness, and richness, which are described below. Analysis of diversity, evenness, and richness is divided into three parts, namely amphibians, reptiles, and the whole herpetofauna species.

Herpetofauna diversity, evenness, and richness

A total of 12 amphibian species and 14 reptile species were found (Selected species can be seen in Figures 2 and 3). Herpetofauna exploration data found in the tributaries of the Brantas River connection in East Java were obtained and then analyzed for the calculation of the diversity, evenness, and richness indices described in Table 2.

A total number of 12 amphibians were found. Based on the analyses using amphibian data only, the diversity index (H') 1 < 1.85 < 3, according to Wilhm and Doris (1986), the criteria for the diversity index are moderate. The value of E is 0.74 > 0.6, based on Krebs (1985) categorically high species uniformity. Specific richness has a value of 2.04 which means the richness index is moderate.

Table 2. Herpetofauna Diversity, Evenness, and Species Richness Index in the Brantas River's streams connection, East Java, Indonesia

Species		Sampling site								∑	H'	E	R
		1	2	3	4	5	6	7	8				
Odorrana hosii	Poisonous Rock Frog	14	0	8	11	3	0	20	0	56	1.85	0.74	2.04
Chalcorana chalconota	White-lipped Frog	1	13	0	9	0	0	13	0	36	Amphibian only		
Limnonectes microdiscus	Indonesia Wart Frog	1	0	0	0	0	0	0	0	1			
Wijayarana masonii	Javan Torrent Frog	1	0	1	7	0	0	0	0	9			
Leptobrachium hasseltii	Hasselt's Litter Frog	5	0	4	0	0	0	61	0	70			
Duttaphrynus melanostictus	Asian Common Toad	6	0	1	4	0	0	1	0	12			
Microhyla achatina	Javan Chorus Frog	1	0	0	0	0	0	0	0	1			
Fejervarya cancrivora	Rice Field Frog	0	8	0	0	0	2	0	0	10			
Philautus aurifasciatus	Gold Striped Tree Frog	0	0	4	0	0	0	7	0	11			
Kaloula baleata	Brown Bullfrog	0	0	0	1	0	1	0	0	2			
Microhyla orientalis	Chorus Frog	0	0	0	1	0	6	0	0	7			
Polypedates leucomystax	Common Tree Frog	0	0	0	0	3	0	0	0	3			
Trimeresurus insularis	White-lipped island pitviper	0	0	0	0	0	1	0	1	2	2.26	0.85	3.37
Fowlea melanzostus	Javanese Keelback Water snake	1	2	0	0	0	0	0	0	3	Reptile only		
Xenochrophis trianguligerus	Triangle Keelback	0	3	0	0	0	0	0	0	3			
Ahaetulla prasina	Asian vine snake	0	1	0	0	0	1	1	0	3			
Eutropis multifasciata	Common Sun Skink	0	1	0	0	0	2	0	0	3			
Cyrtodactylus sp.	Bent-toed Gecko	0	1	0	7	0	3	0	0	11			
Gonocephalus kuhlii	Kuhl's Angl-headed Lizard	0	0	2	0	0	0	0	0	2			
Elapoidis fusca	Dark grey ground snake	0	0	1	0	0	0	0	0	1			
Bronchocela jubata	Maned forest lizard	0	0	2	6	0	0	1	0	9			
Naja sputatrix	Indonesian Spitting Cobra	0	0	0	0	0	0	0	1	1			
Hemidactylus platyurus	Asian House Gecko	0	0	0	0	0	2	0	0	2			
Takydromus sexlineatus	Asian Grass Lizard	0	1	0	0	0	1	0	0	2			
Dendrelaphis pictus	Common Bronze-back	0	0	0	0	0	3	0	0	3			
Gekko gecko	House Gecko	0	0	0	0	0	2	0	0	2			
Total species = 26		30	30	23	46	6	24	104	2	265	2.48	0.76	4.48
											Amphibian and reptile		

Meanwhile, with the reptile only data, we could get the value of diversity index (H') 1 < 2.26 < 3, according to Wilhm and Doris (1986), which is the criteria for the diversity index are moderate. The value of E is 0.85 > 0.6, based on Krebs (1985) categorically high species uniformity. Specific wealth has a value of 3.37 which means that the richness index is moderate.

According to Table 2, both Class of Amphibian and Reptile generated the diversity index (H') 1 < 2.48 < 3, according to Wilhm and Doris (1986), the criteria for the diversity index are moderate. The value of E is 0.76 > 0.6, based on Krebs (1985) categorically high species uniformity. Specific richness has a value of 4.48 which means the richness index is moderate.

Conservation status

IUCN category of 12 amphibian and 14 reptile species can be seen in Table 3.

Discussion

According to the IUCN Red List of the Threatened Species conservation status data, there are five species with low-risk status with decreasing population in nature and two vulnerable species. Species that experienced population decline were *Odorrana hosii, Limnonectes microdiscus, Wijayarana masonii, Leptobrachium hasseltii,* and *Philautus aurifasciatus*. Two species categorically vulnerable, namely *Microhyla orientalis* and *Gonocephalus kuhlii.* Meanwhile, other species are in low-risk status with increase, stable, and unknown population numbers. *Odorrana hosii, Limnonectes microdiscus, Wijayarana masonii, Leptobrachium hasseltii, Philautus aurifasciatus,* and *Microhyla orientalis* experienced a decrease in population size due to certain factors. Amphibian conservation is threatened by one or a combination of various causes, namely capture, habitat reduction, pollution (Alford et al. 2001; Carey and Alexander 2003), and climate change (Blaustein et al. 2010; Corn 2005; Dervo et al. 2016).

Climate is closely tied to habitat conditions and species. Amphibians were viewed as environmental indicators because they are particularly sensitive to temperature and moisture, are centrally nestled in food webs, have complex life histories, and live in both aquatic and terrestrial areas (Deanna 2011). Their numbers tend to plummet first in areas that are just beginning to suffer from environmental degradation. Some research had already been done to examine the amphibians and reptiles population affected by climate change (Bickford et al. 2010; Lopez-Alcaide and Macip-Rios 2011). The last century's abrupt temperature increase could have a major impact on ectotherm organisms, which rely on environmental temperature to maintain body temperatures for physiological metabolism (Zachos et al. 2001; Walther et al. 2002). According to projections, the average temperature of the earth may increase up to 5.8°C (IPCC 2007) at the end of the current century, which represents an enormous threat to biodiversity (McCarty 2001; Parmesan and Yohe 2003). Climate change is linked to the seasons, which affects the breeding patterns (Blaustein et al. 2001; Corn 2005), affecting their habitat, which may be at risk, for example, those found in ephemeral ponds and streams which may dry before the annual reproductive cycle is complete (Olson and Saenz 2013).

Table 5. IUCN and CITES appendices status of Herpetofauna in Brantas River's streams connection

Species	Family	IUCN Status	Population trend	CITES Appendices
Odorrana hosii	Ranidae	Least Concern (2004)	Decreasing	-
Chalcorana chalconota	Ranidae	Least Concern (2017)	Stable	-
Limnonectes microdiscus	Dicroglossidae	Least Concern (2017)	Decreasing	-
Wijayarana masonii	Ranidae	Least Concern (2018)	Decreasing	-
Leptobrachium hasseltii	Megophryidae	Least Concern (2018)	Decreasing	-
Duttaphrynus melanostictus	Bufonidae	Least Concern (2004)	Increasing	-
Microhyla achatina	Microhylidae	Least Concern (2018)	Stable	-
Fejervarya cancrivora	Dicroglossidae	Least Concern (2004)	Increasing	-
Philautus aurifasciatus	Rhacophoridae	Least Concern (2004)	Decreasing	-
Kaloula baleata	Microhylidae	Least Concern (2004)	Stable	-
Microhyla orientalis	Microhylidae	Vulnerable (2018)	Decreasing	-
Polypedates leucomystax	Rhacophoridae	Least Concern (2016)	Stable	-
Trimeresurus insularis	Viperidae	Least Concern (2021)	Unknown	-
Fowlea melanzostus	Colubridae	Not Evaluated	-	-
Xenochrophis trianguligerus	Colubridae	Least Concern (2021)	Increasing	-
Ahaetulla prasina	Colubridae	Least Concern (2021)	Stable	-
Eutropis multifasciata	Scincidae	Least Concern (2018)	Stable	-
Cyrtodactylus sp.	Gekkonidae	-	-	-
Gonocephalus kuhlii	Agamidae	Vulnerable (2021)	Unknown	-
Elapoidis fusca	Colubridae	Least Concern (2012)	Unspecified	-
Bronchocela jubata	Agamidae	Least Concern (2021)	Stable	-
Naja sputatrix	Elapidae	Least Concern (2012)	Unknown	II
Hemidactylus platyurus	Gekkonidae	Least Concern (2021)	Increasing	-
Takydromus sexlineatus	Lacertidae	Least Concern (2021)	Stable	-
Dendrelaphis pictus	Colubridae	Least Concern (2021)	Unknown	-
Gekko gecko	Gekkonidae	Least Concern (2019)	Unknown	II

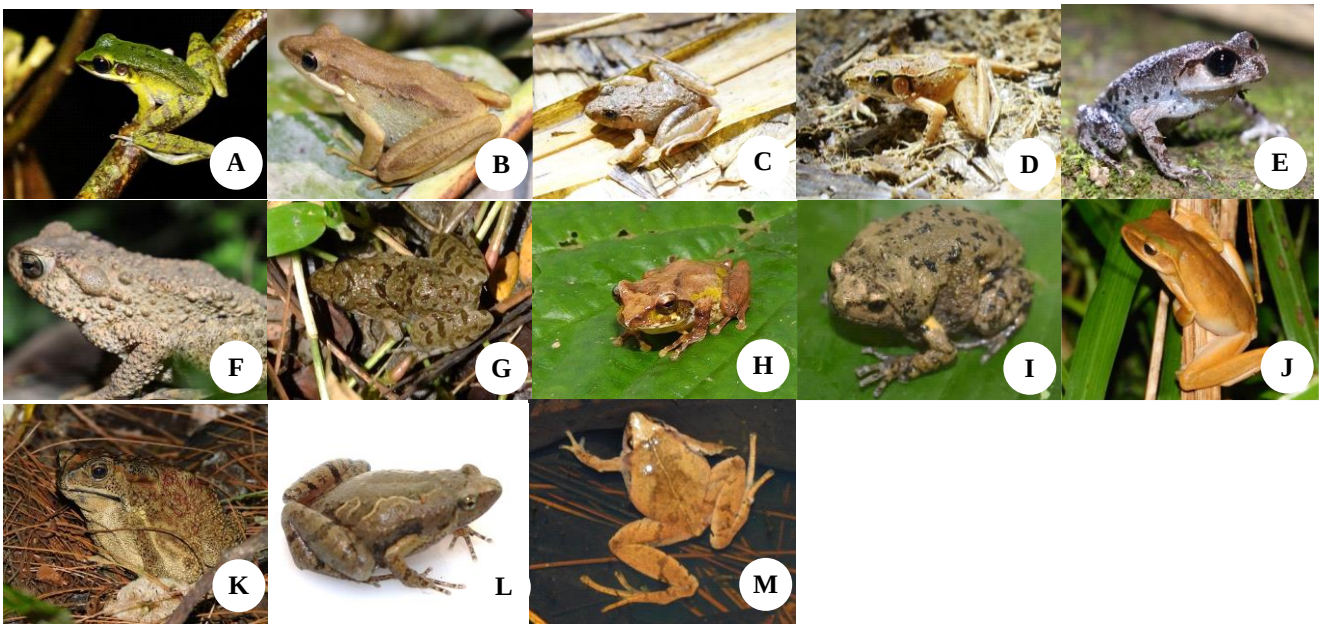

Figure 2. Amphibians found in the Brantas River's streams connection. A. *Odorrana hosii*, B. *Chalcorana chalconota*, C. *Limnonectes microdiscus.* D. *Wijayarana masonii*, E. *Leptobrachium hasseltii*, F. *Phrynoidis aspera*, G. *Fejervarya cancrivora*, H. *Philautus aurifasciatus*, I. *Kaloula baleata*, J. *Polypedates leucomystax*, K. *Duttaphrynus melanostictus*, L. *Microhyla orientalis*, M. *Microhyla achatina*

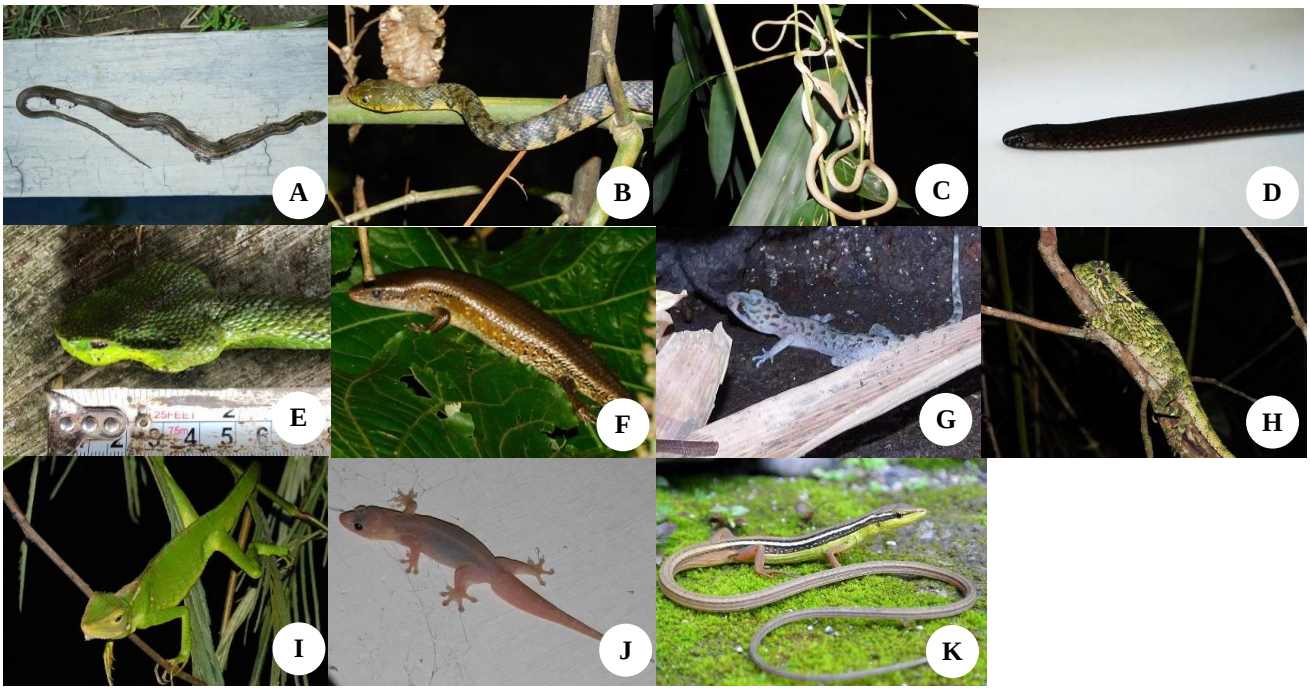

Figure 3. Reptiles found in the Brantas River's streams connection. A. *Fowlea melanzostus* (Death on Road), B. *Xenochrophis trianguligerus*, C. *Ahaetulla prasina*, D. *Elapoides fusca*, E. *Trimeresurus insularis* (FOR), F. *Eutropis multifasciata*, G. *Cyrtodactylus* sp., H. *Gonocephalus kuhlii*, I. *Bronchocela jubata*, J. *Hemidactylus platyurus*, K. *Takydromus sexlineatus*

In addition, environmental changes affect the number of amphibian species populations. The habitat of *Odorrana hosii*, *Microhyla orientalis*and *Wijayarana masonii* is always associated with clear water rivers (Amin 2020). However, the habitat of *Odorrana hosii* has been polluted, resulting in a decline in its population. Yetti et al. (2011); Lusiana et al. (2020); Lusiana et al. (2020) reveal that the Brantas watershed has been polluted chemically,

biologically, and physically. The report by Wirosoedarmo et al. (2015) shows that Brantas river pollution index in 2015 increased from 0.48 to 0.87. Chemical pollution can be caused by the disposal of detergent waste and results in a decrease in water acidity. According to Mattison (1993), a neutral pH value of 6.0-7.0 indicates a general range of pH that can be tolerated by aquatic biota, but some say it is in the range of 6.5-9.0 (Boyd 1982; EPA 1986).

Habitat *Leptobrachium hasseltii* inhabits the floor litter of mountain forests and lowland rain forests, while *Philautus aurifasciatus* has habitats in trees not far from water locations (Amin 2020). The Brantas watershed area in the Regency area is more dominantly used as rice fields, dry land, and forests. While in urban areas (Kediri, Blitar, Malang, Batu, and Mojokerto), the dominant uses are rice fields, dry land, and non-agriculture (Wirosoedarmo et al. 2015). The conversion of green open land into agricultural land causes both species to lose their natural habitat. According to GAA (2006), deforestation causes some amphibian species are experiencing declines in their habitats. However, based on the exploration carried out, many species, namely *Odorrana hosii*, *Wijayarana masonii*, *Leptobrachium hasseltii*, *Microhyla orientalis*, and *Philautus aurifasciatus* were found. This is because the three species have properties that are highly dependent on water and have good self-defense from predators (Qurniawan and Trijoko 2012).

In conclusion, there were 12 species of amphibians and 14 species of retile were found in Brantas River. Five species are of low-risk status with decreasing population in nature and two species is of vulnerable status. Species in the declining category are *Odorrana hosii*, *Limnonectes microdiscus*, *Wijayarana masonii*, *Leptobrachium hasseltii*, and *Philautus aurifasciatus.* Species in the vulnerable category are *Microhyla orientalis* and *Gonocephalus kuhlii.* The diversity index (H') of herpetofauna found in Brantas River was $1 < 2$, $3959 < 3$, with the criteria for the diversity index being moderate. The value of e is $0.74 > 0.6$, which means high species uniformity. Specific richness has a value of 4.53 which means in the moderate category. The diversity index (H') of amphibian was $1 < 1.856 < 3$, categorically moderate. The value of E was $0.747 > 0.6$, categorically high species uniformity. Specific richness has a value of 2.043 which means the richness index is moderate. The diversity index of reptile was (H') $1 < 2.260 < 3$, categorically moderate. The value of E is $0.856 > 0.6$, categorically high species uniformity. Specific wealth has a value of 3.376 which means that the richness index is moderate. The conservation status of the whole species is still at low risk and vulnerable, however, efforts must be made to start conservation efforts to preserve the entire biodiversity because each creature has its role in the balance of the ecosystem.

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