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RESEARCH ARTICLE

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Diversity, abundance, and evenness of lizards and snakes (Reptilia: Squamata) in Winongo River, Province of DIY

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Abstract

River is one of the habitats for reptiles. Based on the research along Code, Opak, and Gadjahwong Rivers, reptiles commonly found along rivers in Yogyakarta were lizards and snakes. Research on lizards and snakes' diversity is essential to know its diversity and to understand its habitat along rivers in Yogyakarta. Methods used were visual encounter survey combined with time search. Data analysis was using Shannon-Wiener Index, Pielou Evenness Index, and degree of abundance. Nine lizard and 15 snake species were obtained. Lizard and snake diversity based on the Shannon-Wiener Index on upstream, midstream, and downstream was categorized as low with 0.246, 0.228, and 0.185 as well as low with 0.099 and moderate with 0.182 and 0.135. Lizard and snake evenness based on Pielou Index was categorized as low with 0.178; 0.127, and 0.115 as well as 0.099, 0.182, and 0.135, respectively. Most abundant lizards were *Eutropis multifasciata* and *Bronchocela jubata*. Meanwhile, snakes were dominated with *Dendrelaphis pictus*, *Ahaetulla prasina*, and *Homalopsis buccata*.

Keywords: Diversity; Abundance; Lizards; Snakes; Winongo River

Introduction

River area is one of the potential habitats for reptiles such as lizards, snakes, monitor lizards, crocodiles and turtles. Based on the research Code (2012), Opak (2013), and Gadjah Wong Rivers (2014), reptiles commonly found along river area in Province of Dareah Istimewa Yogyakarta (DIY) were lizards

and snakes[1–3]. Crocodiles, turtles, and softshell turtles were not found during the sampling. Softshell turtles rarely found and usually found accidentally when it caught on fishhook of fishermen. Most reptiles are disliked by human, therefore when reptiles occur, human tend to catch and moved to other place or kill them. Crocodiles, turtles and softshell turtles are reptiles that quite easy to catch compare to lizards and snakes. Nowadays, more human utilizes river bank as settlement or sites for plant farming and fish farming. Therefore, natural condition on river bank mostly transformed.

Winongo River is one of the rivers which flow across the DIY. It is located on western side of the City of Yogyakarta with 48 km in length from upstream to downstream. Human activities along the river are high. That condition could affect the existence of reptiles. Reptiles which inhabit this habitat is not yet recorded. Research on the diversity of lizards and snakes is essential to know its diversity and to understand its habitat along and near the river area in DIY. Publications concerning the diversity of lizards and snakes along river area in Province of DIY have been done on Code, Opak dan Gadjahwong River. Research and publication concerning the diversity of lizards and snakes along Winongo River has not been done.

Material and methods

Study area

Specimens of lizards and snakes were collected from its habitats along the Winongo River from the upstream, midstream, and downstream of the DIY province (**Figure 1**). Chemicals used to preserve voucher specimens were alcohol 70%, 4% formaldehyde, distillate water, and chloroform.

Figure 1. Winongo River (blue line); (a) Upstream part; (b) Midstream part; and (c) Downstream part (source: modification from google maps).

Research was conducted during May to September 2015. Research location was along the Winongo River from its upstream located on the northern part of Yogyakarta (Sleman Regency) to downstream which fused with Opak River located on the southern part of the province (Bantul Regency) (**Figure 1**, **Table 1**). The method used was line transect along 500 m per sampling point combined with visual encounter surveys (VES), river bank cruising by Line Distance and time search[4,5]. Transect line

along 500 m was made in middle part of the body of water. Transect line was also made using the handheld global positioning system (GPS).

Table 1. Sampling locations along Winongo River from upstream to downstream

River Part	Code	Location	Coordinate
Upstream	SP I	Donokerto Village, Turi District, Sleman Regency	S 07° 39' 48.3"; E 110° 22' 51.6"
	SP II	Pandowoharjo Village, Sleman District, Sleman Regency	S 07° 41' 84.48"; E 110° 22' 22.07"
	SP III	Pandowoharjo Village, Sleman District, Sleman Regency	S 07° 41' 56.1"; E 110° 22' 02.1"
Midstream	SP I	Trihanggo Village, Gamping District, Sleman Regency	S 07° 44' 56.2"; E 110° 21' 08.3"
	SP II	Kricak Village, Tegalrejo District, Yogyakarta Municipal	S 07° 45' 59.5"; E 110° 21' 07.7"
	SP III	Suryowijayan Village, Gedongkiwo District, Yogyakarta Municipal	S 07° 45' 44.3"; E 110° 22' 32.8"
Downstream	SP I	Tirtonirmolo Village, Kasihan District, Bantul Regency	S 07° 45' 44.3"; E 110° 22' 32.8"
	SP II	Donotirto Village, Kretek District, Bantul Regency	S 07° 58' 48.3"; E 110° 18' 48.2"
	SP III	Donotirto Village, Kretek District, Bantul Regency	S 07° 59' 20.1"; E 110° 18' 47.4"

SP = Sampling Point

Procedure

To facilitate the research, we divided the river into 3 parts i.e., upstream, midstream and downstream. We decided that river part located on the northern part of north Ring Road (upstream), inside the Ring Road (midstream), and on the southern part of south Ring Road (downstream) then established 3 sampling points in each part (**Table 1**). Data collection was done twice a day on each sampling points, which were day and night. Sampling during the day was expected to encounter diurnal reptiles, while sampling in the evening was in order to get the nocturnal ones. It was done to maximize the number of species expected to be found in the area.

All snakes and lizards specimens found during sampling were collected, identified, and documented with sampling was done along the river. An individual of each species was taken as voucher specimens[6]. Specimen preserved using alcohol 70% and labeled. Identification was done based on Manthey (2008) for agamid lizards, de Rooij (1915 and 1917), and Das (2010) for lizards and snakes[7–10].

Data analysis

Data acquired then analyzed with Shannon-Wiener Diversity Index, Pielou Evenness Index, and degree of abundance by Buden (2000)[11–14].

Shannon-Wiener diversity index[15–18]

H′ = -Σ Pi Ln Pi

H′ = Shannon-Wiener diversity index

Pi = Proportion of each species in the sample ($\frac{ni}{Ni}$)

ni = Number of individuals belonging to i species

Ni = Total number of individuals

Shannon-Wiener index category:

H′ <1 = low.

H′ 1-3 = moderate.

H′ >3 = high.

Degree of species abundance[14]

Common = >30 individuals/day

Fairly common = 10–29 individuals/day

Uncommon = 6–9 individuals/day

Scarce = <5 individuals/day

Pielou evenness index[11,19,20]

E = H/ln S

E = Pielou evenness index

H = Shannon-Wiener diversity index

S = Total number of species

Pielou evenness index category:

0 < E <0.5 = dominance in the community, some populations are stressed.

0.5 < E <0.75 = unstable population.

0.75< E <1 = stable community.

Result

Diversity of lizards in the upstream part of Winongo River was consist of 4 species, i.e.: *Eutropis multifasciata*, *Cyrtodactylus marmoratus*; *Bronchocela jubata*, and *Hemidactylus platyurus*. While in the midstream was consisting of 6 species, i.e.: *Eutropis multifasciata*, *B. jubata*, *H. frenatus*, *Gekko gecko*, *H. platyurus*, and *Varanus salvator*. And in the downstream was consist of 5 species of lizards, i.e.: *E. multifasciata*, *B. jubata*, *V. salvator*, *Gehyra mutilate*, and *Draco sp*. Lizard diversity based on Shannon-Wiener index, on upstream, midstream and downstream were categorized as low with H′ 0.246, 0.228, and 0.185 respectively (**Figure 2**). Value of Pielou evenness index for lizards on upstream was 0.178, on midstream was 0.127 and on downstream was 0.115 (**Figure 3**).

Table 2. Lizards observed along Winongo River.

Upstream part of Winongo River					
No	**Suborder**	**Family**	**Species**	**Number of individuals**	**Degree of abundance (Buden 2000)**
1.	Lacertilia	Scincidae	*Eutropis multifasciata*	36	Common
2.		Agamidae	*Bronchocela jubata*	43	Common
3.		Gekkonidae	*Cyrtodactylus*	8	Uncommon

			marmoratus		
4.			*Hemidactylus platyurus*	1	Scarce
Midstream part of Winongo River					
1.	Lacertilia	Scincidae	*Eutropis multifasciata*	13	Fairly common
2.		Agamidae	*Bronchocela jubata*	14	Fairly common
3.		Gekkonidae	*Hemidactylus platyurus*	2	Scarce
4.			*Gekko gecko*	1	Scarce
5.		Varanidae	*Varanus salvator*	1	Scarce
Downstream part of Winongo River					
1.	Lacertilia	Scincidae	*Eutropis multifasciata*	43	Common
2.		Agamidae	*Bronchocela jubata*	21	Common
3.			*Draco* sp.	2	Scarce
4.		Gekkonidae	*Gehyra mutilata*	1	Scarce
5.		Varanidae	*Varanus salvator*	2	Scarce

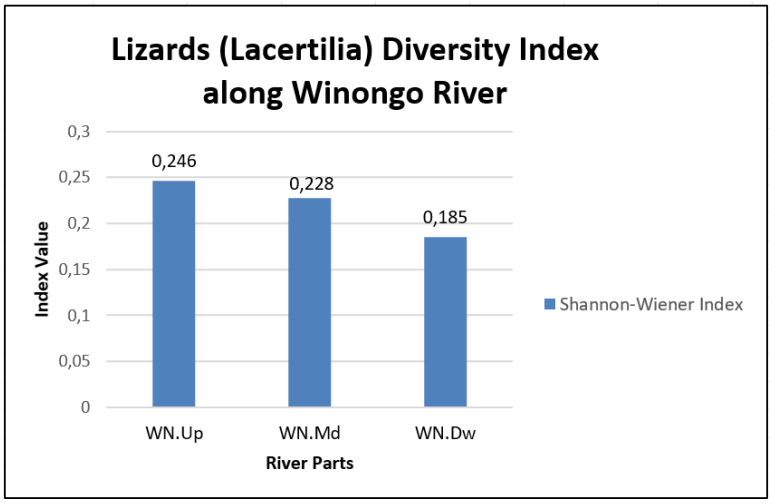

Figure 2. Shannon-Wiener Diversity Index of lizards (lacertilia) in Winongo River. WN.Up = Upstream of Winongo River; WN.Md = Midstream of Winongo River; WN.Dw = Downstream of Winongo River.

Diversity of snakes in the upstream part of Winongo River was consist of 8 species, i.e.: 4 species of arboreal snakes *Dendrelaphis pictus*, *Ptyas korros*, *Ahaetulla prasina*, and *Gonyosoma oxycephala*; terrestrial snake *Coelognathus radiatus*, and 3 species of water snakes with details 2 species of semi-aquatic *Xenochrophis trianguligerus*, *X. vittatus*, and a species of aquatic freshwater snake *Homalopsis buccata*. Otherwise, in the midstream was consisting of 5 species: *A. prasina*; 2 species of terrestrial snakes *Malayopython reticulatus*, and *Naja sputatrix*, and 2 species of semi-aquatic snakes *X. trianguligerus*, and *Rhabdophis subminiatus*. Additionally, in the downstream was consist of 7 species: 3 species of arboreal snakes *D. pictus*, *A. prasina*, and *Boiga dendrophila*; 2 species of terrestrial snakes *N. sputatrix* and *Bungarus candidus*, 1 species of fossorial snake *Indotyphlops braminus*, and 1 species of aquatic snake *H. buccata* (**Table 3**). Then, diversity of snakes based on Shannon-Wiener index, on upstream was 0.099 and categorized as low diversity; on midstream and downstream were 0.182 and 0.135 categorized as

moderate diversity (**Figure 4**). Value of Pielou evenness index for snakes on upstream, midstream, and downstream were 0.099, 0.182, and 0.135 (**Figure 5**).

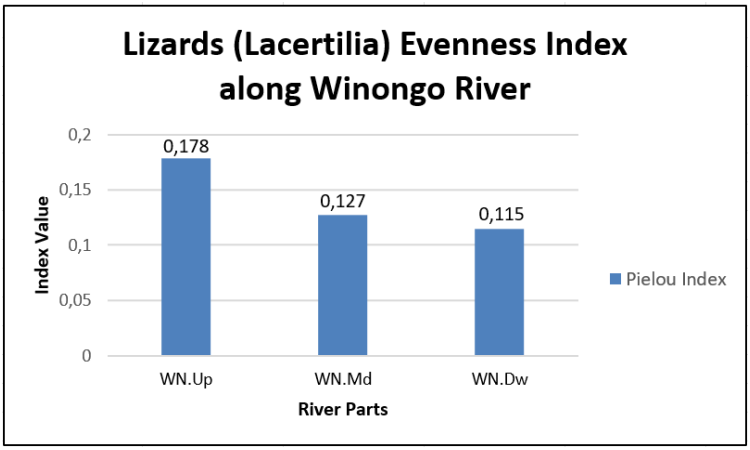

Figure 3. Pielou Evenness Index of lizards (lacertilia) in Winongo River. WN.Up = Upstream of Winongo River ; WN.Md = Midstream of Winongo River; WN.Dw = Downstream of Winongo River.

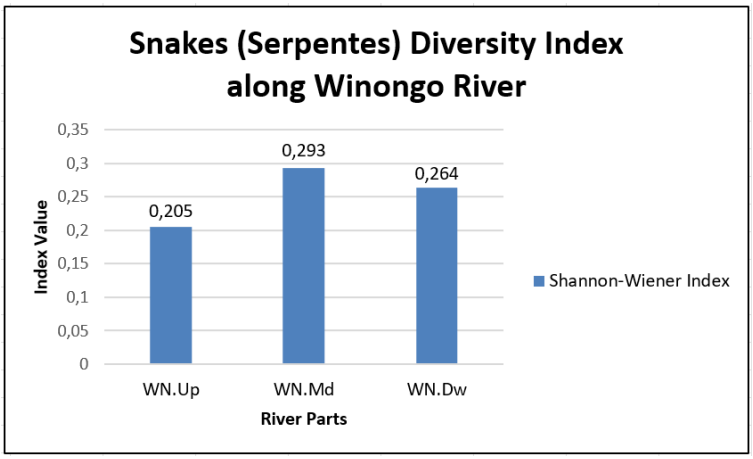

Figure 4. Shannon-Wiener Diversity Index of snakes (serpentes) in Winongo River. WN.Up = Upstream of Winongo River; WN.Md = Midstream of Winongo River; WN.Dw = Downstream of Winongo River.

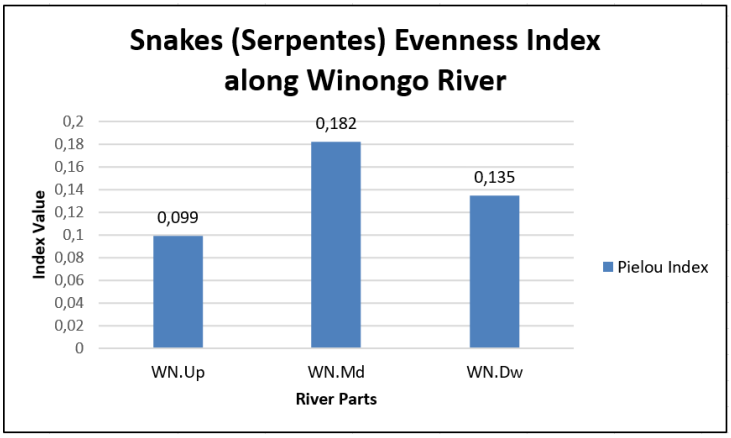

Figure 5. Pielou Evenness Index of snakes (serpentes) in Winongo River. WN.Up = Upstream of Winongo River; WN.Md = Midstream of Winongo River; WN.Dw = Downstream of Winongo River.

Table 3. Snakes observed along Winongo River.

Upstream part of Winongo River					
No	**Suborder**	**Family**	**Species**	**Number of individuals**	**Degree of abundance (Burden 2000)**
1.	Serpentes	Colubridae	*Dendrelaphis pictus*	17	Fairly common
2.			*Ahaetulla prasina*	15	Fairly common
3.			*Ptyas korros*	1	Scarce
4.			*Coelognathus radiatus*	1	Scarce
5.			*Gonyosoma oxycephala*	4	Scarce
6.		Natricidae	*Xenochrophis trianguligerus*	2	Scarce
7.			*Xenochrophis vittatus*	2	Scarce
8.		Homalopsidae	*Homalopsis buccata*	10	Fairly common
Midstream part of Winongo River					
1.	Serpentes	Colubridae	*Ahaetulla prasina*	3	Scarce
2.		Natricidae	*Xenochrophis trianguligerus*	1	Scarce
3.			*Rhabdophis subminiatus*	1	Scarce
4.		Pythonidae	*Malayopython reticulatus*	3	Scarce
5.		Elapidae	*Naja sputatrix*	1	Scarce
Downstream part of Winongo River					
1.	Serpentes	Colubridae	*Dendrelaphis pictus*	3	Scarce
2.			*Ahaetulla prasina*	3	Scarce
3.			*Boiga dendrophila*	1	Scarce
4.		Homalopsidae	*Homalopsis buccata*	2	Scarce
5.		Elapidae	*Naja sputatrix*	1	Scarce
6.			*Bungarus candidus*	2	Scarce
7.		Typhlopidae	*Indotyphlops braminus*	1	Scarce

Discussion

Low value of lizard species diversity index on upstream was due to the number species encountered, there were only 4 species found in upstream. From those 4 species, there were 2 species i.e., *E. multifasciata* and *B. jubata* dominated because was found in a very large number of individuals compare the other species. This case also similarly occurs on midstream and downstream (**Figure 2**; **Table 2**). Those 2 species of lizards observed in a large number of individuals on upstream to downstream be occupied in different habitat. *E. multifasciata* is a terrestrial lizard which occupies terrestrial part of riverbank yet *B. jubata* is an arboreal lizard which occupies riparian vegetation along the riverbank[14].

Midstream part was the area where lizards were most diverse with 6 species found. It was also the most disturbed part because there were a lot of human settlements which very close to the river body. There were also human activities during the day like washing clothes, sand mining, fishing, and children playing along the riverbank. The most diverse species number of lizards found in disturbed

habitats was assumed that those 6 species were lizards that are able to adapt with human existence and activities. From those 6 species, 3 of them were classified as house gecko (*H. frenatus*, *G. gecko*, and *H. platyurus*). House geckos are lizards which commonly found in and around human settlements. Those use lighting of human houses as areas for food foraging. The lighting in human houses is often infested by insects as their preys[8].

Lizard species abundance on upstream, midstream, and downstream part the Winongo River based on Buden (2000)[14] method were belonging to these two species: *E. multifasciata* and *B. jubata*. They were categorized as common with 36 and 43; 13 and 14; and 43 and 21 individuals, respectively (**Table 2**).

E. multifasciata is a terrestrial lizard which prefer habitat with shrubs, rocks with grass and moist soil. The abundance of this species indicates that along riverbank there were shrubs, grasses, rocks and moist soil. Meanwhile, *B. jubata* is an arboreal lizard which live on tree branches and its abundance indicate that along the riverbank there were plenty of riparian vegetation, and these riparian vegetations were dense and widespread in several spots (**Figure 6-7**). The abundance of *B. jubata* and *E. multifasciata* populations along the Winongo River is because those two species were being able to live in disturbed habitats. *B. jubata* are not bothered by human presence and activities because they live on trees. As long as human activities on riverbanks do not damage the riparian vegetation, *B. jubata* habitat and their existence will be maintained. *E. multifasciata* is a reptile that can adapt to human activities because it is a terrestrial lizard. Their nest and hiding places are in rock crevices or holes in the ground so they will safely hide when there is human activity around riverbanks[9].

Based on Pielou evenness index, the lizard community distribution on upstream, midstream, and downstream part was not balanced. It indicated that there was some species have higher abundances or dominated yet the remaining ones were scarce and stressed. Those dominant species from upstream to downstream be the same species, i.e., *E. multifasciata* and *B. jubata* (**Figure 8A-B**). On upstream, these dominant species with a number of individuals was 4-5 times larger compare to the others. Meanwhile, the midstream 3 times and downstream was 10-20 times (**Table 2**). Those 2 dominant species were existed along the river because riparian vegetation was dense and widespread in several spots (**Figure 6-7**). It also did not destructed by human activities so it can always support the existence of the species[4].

C. marmoratus is a terrestrial lizard which only found along the upstream. This gecko prefers terrestrial rocky habitat along the riverbank. The upstream riverbank was rocky terrestrial and less human activities. Therefore, it could be suitable habitat for this bent-toed gecko. Meanwhile, *Draco sp*. is an arboreal lizard which only could be observed in downstream. This flying dragon inhabited areas of high trees so it was making them difficult to observe and to identify until species level[5].

Low snake diversity on upstream part means that snake community was dominated by few species (**Figure 4**; **Table 3**). There were 8 snakes species found, in which three of them number of individuals more than 10 had or dominated the community (**Table 3**). Those 3 dominated species were *D. pictus*, *A. prasina*, and *H. buccata*. *D. pictus* and *A. prasina* are arboreal snakes and mostly found on riparian vegetation along river banks. Meanwhile, *H. buccata* is an aquatic snake and it's found in the water body. On the other hand, Homalopsis buccata snake mostly feed on fish and other aquatic animals and it is rarely out of the water. These 3 snake species can be categorized as resident snakes, the arboreal

snakes, and the aquatic one. Meanwhile, the other 4 species, with fewer individuals, are likely non-resident snakes. They were found moving through the river as a part of their activities[7].

On midstream part, there were 5 snakes species found with relatively similar number of individuals each species. Therefore, Shannon-Wiener index was moderate (**Figure 4**). Three from five species were semi-aquatic snakes (*X. trianguligerus*, *R. subminiatus*, and *M. reticulatus*), one arboreal snake (*A. prasina*), and one terrestrial snake (*N. sputatrix*). The presence of these 5 species was difficult to categorize as resident snakes because the number of individuals encountered was ≤3 individuals. Besides, on downstream part, there were 7 species found with almost evenly distributed individuals between 1 and 3 (**Table 3**). However, Shannon-Wiener index was moderate (**Figure 4**). They were arboreal snakes (*D. pictus*, *A. prasina*, and *B. dendrophila*), aquatic species (*H. buccata*), terrestrial snakes (*N. sputatrix* and *B. candidus*), and one fossorial (*I. braminus*). The presence of them was difficult to categorize as resident snakes because number of individuals encountered was ≤3 individuals (**Table 3**).

Snake species abundance on upstream part was belonging to the *D. pictus*, *A. prasina*, and *H. buccata*. These were categorized as fairly common with number of individuals encountered was 17, 15 and 10 individuals respectively. Meanwhile, the abundance on midstream and downstream parts were categorized as scarce with number of individuals encountered was 1-3 individuals (**Table 3**).

Based on Pielou evenness index, the snake community distribution on upstream, midstream, and downstream part were not balanced. It is indicated there was some species have higher abundances while the remains were scarce and stressed (**Figure 5**; **Table 3**). The dominant species from upstream like *D. pictus* and *A. prasina* had 3-4 times larger (**Figure 9**). Aside, on midstream and downstream, there were no dominant species. Some species only 3 times larger compare to the others. The most dominant species were 2 arboreal and 1 aquatic species. Those 2 arboreal species were existed along the river because riparian vegetation was dense and widespread in several spots (**Figure 6-7**). Riparian did not destructed by human activities during sampling. Therefore, it can always support the existence them (**Figure 9A-B**)[20].

In addition to *H. buccata*, 2 species of semi-aquatic snakes were also found in the Winongo River: *X. trianguligerus*, and *X. vittatus*. Both snakes prefer stagnant or still water habitats, as well as slow-moving, shallow water[18]. Observations showed that these two semi-aquatic snakes were commonly found in small rivers around rice fields, far from human activity. The presence of them indicates that the water in the Winongo River is constantly flowing, and at some points, was deep and still or pools (**Figure 10A**).

Conditions along the banks of Winongo River midstream revealed a large amount of human waste piled high (**Figure 10B**). The abundance of waste, especially organic waste, attracts chickens and rats. During daytime observations and sampling, several chicks and rats were also found on the riverbank. The presence of chickens and rats attracted *M. reticulatus*[1]. This python was observed at 2 sampling points along the Winongo River that passes through the city. Chickens and rats are the pythons' natural and primary prey.

Presence of a mangrove snake, *B. dendrophila* on downstream near the midstream of the Winongo River (near the city) is unusual (**Figure 11A**). This snake was usually found in the downstream and estuaries with riparian mangrove vegetation[2]. Presence mangrove snakes are likely accidentally released from a pet or snake collector, because the area around the downstream of sampling point 1 (SP.1) is a

place for animal markets and snake collectors. Meanwhile presence of two *H. buccata* water snakes indicates that the river water is quite deep and wide and relatively clears with a fairly large number of fish. The presence of fish and frogs is also quite abundant considering the presence of water snakes as predators of fish and frogs.

Presence of two highly venomous *B. candidus* and *N. sputatrix*, indicates that the riverbanks are moist, with rocks and bamboo trees in between, and are close to rice fields. Bungarus candidus prefer flat areas around rivers and small ditches near rice fields, while Javanese spitting cobras prefer damp, rocky, sloping holes, especially along riverbanks. We also encounter *I. braminus* which is a small, fossorial snake (**Figure 11B**). Presence of this species indicates that the riverbanks are close to rice fields or shrubs, with sufficient moisture and cool temperatures[3]. Furthermore, the riverbanks have riparian vegetation with fibrous roots and soil with small, deep cracks (**Figure 10C**).

Conclusions

Lizard diversity on Winongo River was categorized as low diversity. Meanwhile, snake diversity was categorized as low and moderate diversity. Lizard and snake evenness were categorized as stressed community. Lizard species abundance along was dominated by *E. multifasciata* and *B. jubata*. Furthermore, snake species was dominated by *D. pictus*, *A. prasina*, and *H. buccata*, and those species categorized as fairly common. There was no species abundance on midstream and downstream, all snake species found on midstream and downstream were categorized as scarce.

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Conflicts of Interest

There are no any potential conflicts of interest are noted.

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