

RESEARCH ARTICLE



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The Abundance of *Leptophryne javanica* in the Streams of Mount Ciremai National Park

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Abstract

Leptophryne javanica is a frog in West Java and Central Java. Threats to the presence of *L. javanica* in nature include volcanic activity and chytrid fungi. The population of *L. javanica* is not known for certain. This study aims to estimate the abundance of *L. javanica* in several streams of Mount Ciremai National Park and describe the habitat of this species. This research was conducted in Cisurian Waterfall, Cilutung Waterfall, Ciinjuk Spring, and Cilengkrang Waterfall using visual encounter methods combined with sampling transect. *L. javanica* was found mostly in Ciinjuk Springs with an abundance of 2.50 ± 3.09 ind /10 m. More males were found than females, except in the Cisurian Waterfall. The body size and weight of the females were larger than the males. The microhabitat of Ciinjuk Spring had an average of river currents of 0.34 m/s, river width of 0.8–1.2 m, river depth of 1.0–3.4 cm, and canopy density ranging from 54.17–100%. In addition to the spring, the waterfall was also a preferred habitat by *L. javanica*. Further research is needed in other waterfalls and rivers with microhabitat characteristics similar to Ciinjuk Spring.

Keywords: abundance, frog, habitat, *Leptophryne javanica*, Mount Ciremai National Park

1. Introduction

Leptophryne javanica is one of the three species of the genus *Leptophryne*, the other two being *Leptophryne cruentata* and *Leptophryne borbonica*. All three are small frogs with body lengths less than 4 cm [1]. *L. borbonica* has a relatively wide distribution, found in Peninsular Malaysia, Borneo (Sabah, Sarawak, Brunei Darussalam, Kalimantan), southern Thailand, and Indonesia (Sumatra and Java) [2]. *Leptophryne cruentata* and *Leptophryne javanica* had limited distribution. Before being described as *L. javanica*, this species was considered the same as *L. cruentata*, which is found in Mount Halimun Salak National Park (TNGHS) and Mount Gede Pangrango National Park (TNGGP) [3]. The habitats of *L. javanica* are located across two provinces, West Java and Central Java. In West Java, the species is found in three areas: Mount Kencana Protected Forest and Mount Tilu Nature Reserve in Pengalengan; Bandung, Mount Sawal Wildlife Reserve in Pasir Tamiang; Cihaurbeuti, Ciamis, and Mount Ciremai National Park in Kuningan and Majalengka. In Central Java, this species is found on Mount Slamet [1,4]. This frog is suspected to be endemic to the mountains of central Java at elevations of 1200–1500 meters above sea level [1]. The distribution range of *L. javanica* is likely to increase because it is suspected that several waterfalls or springs around its current habitat have not yet been surveyed.

Mount Ciremai National Park (TNGC) is one of the national parks on the island of Java, and it has habitats for various wildlife species. There are 22 bird species in the Buffer Zone [5], nine large mammal species [6], 16 amphibian species, and 27 reptile species [7]. In addition, TNGC is highly attractive for natural tourism. The Ipuhan Campground (Buper Ipuhan) is one of the most attractive locations for natural tourism. The number of visitors increased significantly from 2016 to 2017, with an additional 73,800 visitors. By 2020, Buper Ipuhan had attracted no fewer than 30,000 visitors annually [8–12].

The existence of *L. javanica* in the wild is threatened by volcanic activity and chytrid fungus. Although Mount Ciremai and Mount Slamet are volcanoes, they have remained inactive for several hundred years [1]. The chytrid fungus, which has caused global amphibian decline [13], has been found in several frog species in Mount Gede Pangrango National Park [14]. It

is possible that the chytrid fungus is present in the Mount Ciremai National Park and can infect *L. javanica*, which belongs to the same genus as *L. cruentata*.

However, the population of *L. javanica* is not well known. According to Hamidy [1], only two individuals were found in the Cisurian Waterfall. In contrast, Kholik [15] reported 307 individuals based on observations at five locations: Cisurian Waterfall, Cilutung Waterfall, Kopi Bojong Spring, Ciinjuk Spring, and Batu Nganjut Waterfall. Unfortunately, this report does not specify the data collection methods, duration of observations, or the area surveyed; therefore, this figure does not indicate the population size of this frog in each stream.

Therefore, this study was conducted in several streams of the TNGC to determine the abundance of *L. javanica* in various streams and to describe the microhabitat and other frog species in the same habitat. Studying the microhabitats of *L. javanica* is important because it contributes to the conservation of this species.

2. Research Methodology

2.1. Study Area

Data were collected on four transects in two streams in the southeastern area of Mount Ciremai National Park from April 9 to 26, 2021. The first transect was Cisurian Waterfall (230 m), the second was Cilutung Waterfall (500 m), the third was Ciinjuk Spring (300 m), and the fourth was Cilengkrang Waterfall (1000 m). The length of each transects varies according to the river length (Table 1 Figure 1).

Table 1. Conditions of the research site: Cisurian Waterfall, Payung Waterfall, Cilutung Waterfall, Ciinjuk Spring, and Cilengkrang Waterfall.

Location	Length of transect (m)	Date of data collection	Notes
Cisurian and Payung Waterfall	230	April 10–11 and 16, 2021	Near the campsite, frequently visited by people, after 220 meters, there is another waterfall with a river flow length of 10 meters.
Cilutung Waterfall	500	April 12–14, 2021	Above Cisurian Waterfall, which is rarely visited by people, water is distributed to the community. Observations were not made around 20 meters of the river with a too strong current.
Ciinjuk Spring	300	April 18–20, 2021	Water is distributed to the community, which is rarely visited by people. According to the locals who act as guides, accessing this river flow is difficult, so the river's total length is unknown.
Cilengkrang Waterfall	1000	April 22–25, 2021	In the tourist area, there are hot springs near the waterfall, which are visited by many people. The length of this flow is unknown.

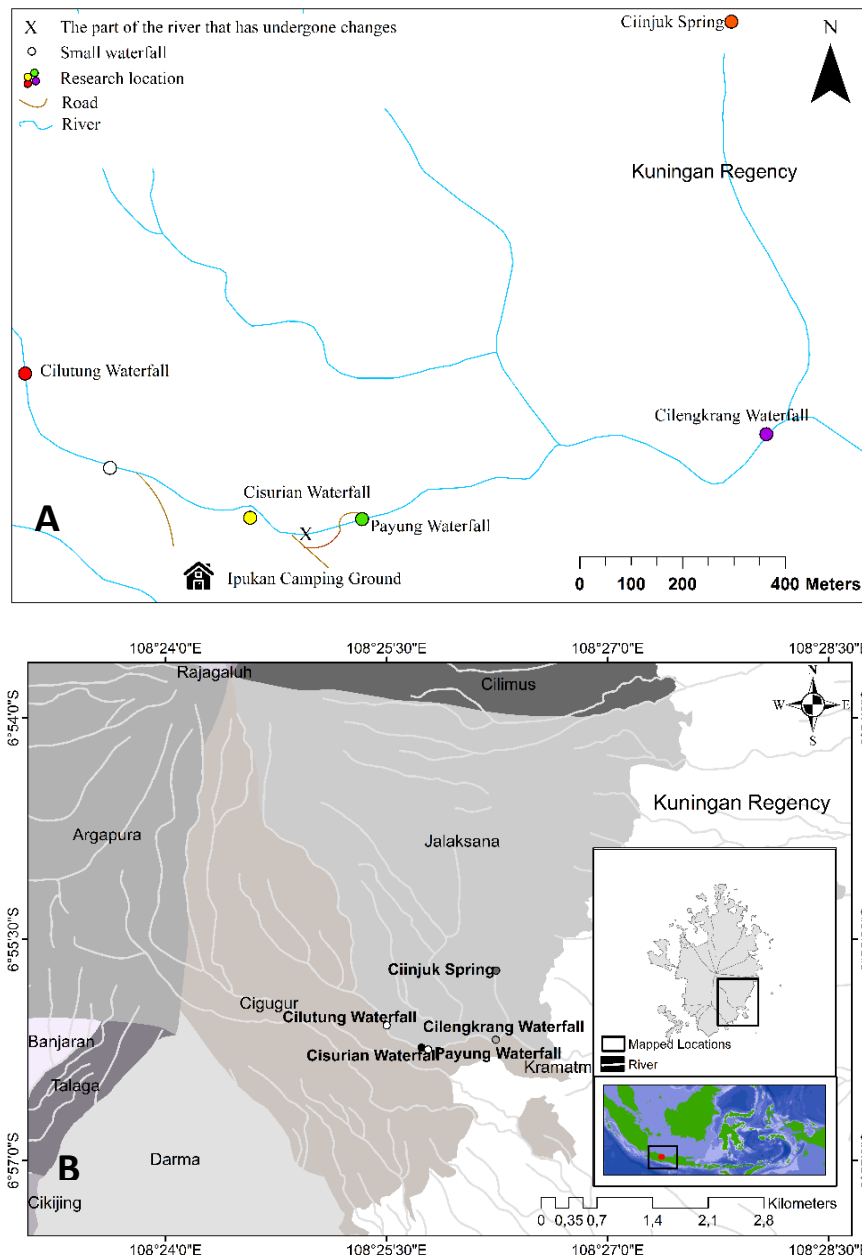


Figure 1. Sketch of the research location (A) and map of the research location (B) in several rivers of Mount Ciremai National Park: Cisurian Waterfall, Payung Waterfall, Cilutung Waterfall, Ciinjuk Spring, and Cilengkrang Waterfall.

2.2. Data Collection of Frog Species and Individuals

Frog data were collected using the Visual Encounter Survey (VES) method and transect sampling to determine the distribution range around the waterfall and locations of the frogs. Transects were set up along the river, with the width matching that of the river. Marking within the transects was conducted during the day or evening before the observations on the following day. Partial data on microhabitat characteristics were also collected, including air temperature, air humidity, water temperature, water pH, water clarity, canopy density, dominant habitat, length, width, depth, and river substrate. Marking was performed every 10 m using numbered tape corresponding to the transect length.

The total observation effort was 95 h and 25 min per person. The number of observers and data collection times varied between locations. The overall search effort for *L. javanica* and other frog species at each location is presented in Table 2.

Table 2. Search duration (effort) for *L. javanica* and other frog species at each location.

Location	Length of transect (m)	Total Day	Total Observations (hour:minute)	Observers (people)	Effort (hour:minute observes-people)
Cisurian Waterfall	100	1	1:55	6	11:30
	120	1	1:31	3	4:33
	10	1	1:43	3	5:09
Cilutung Waterfall	500	2	5:15	3	15:45
Ciinjuk Spring	300	2	8:07	4	32:28
Cilengkrang Waterfall	1,000	4	8:40	3	26:00
Total (hour-observers)					95:25

The collection of frog species and individual data, as well as microhabitat characteristics, started from the waterfall, except at the Ciinjuk Spring, where the waterfall or the source of the spring is unknown. Each *L. javanica* specimen was captured and placed in a plastic bag for weight and snout-vent length (SVL) measurements and documentation. Weight measurements were taken using a spring scale, while SVL measurements were taken using calipers. The measured frogs were then released into their habitats. Data recorded when *L. javanica* was found included the time, substrate, activity, sex, and position at the time of discovery.

Other frog species encountered along the observation route were captured for identification, but were not weighed or measured for body size and sex. The number and species of frogs, including their location, substrate, position, and activity at the time of discovery, were recorded. Searches for eggs and tadpoles were conducted day and night along riverbanks, suspected of being tadpole habitats. Tadpoles found were grouped based on Gosner stages according to Ningsih et al. [16], which divided them into four groups. In this study, the grouping proposed by Ningsih [16] was further categorized. Stages 36-46 and 41-46 were combined into stages >35. After identification, the tadpoles returned to their original locations. GPS was used during observations to mark the transect points and locations where *L. javanica* was found, enabling the determination of their distribution. The frogs and tadpoles found were then identified using the Illustrated Guide for Amphibian Identification of West Java [17] and Amphibians of Java and Bali [18]. Frog species were identified based on the Amphibian Species of the World 6.1.

2.3. Collection of Microhabitat Characteristic Data

Microhabitat characteristic data were collected during both the day and night. Data recorded during the day included weather conditions (sunny, cloudy, rainy, and after rain), air temperature, air humidity, water temperature, water pH, water clarity, canopy density (very dense (81–100%), dense (61–80%), moderately open (41–60%), open (21–40%), and very open (0–20%) [19]), dominant habitus (trees, shrubs, bushes, herbs, and understory vegetation), length, width, depth, and river substrate (sand, mud, rocks, and gravel) [20,21]. Data recorded at night included weather conditions, air temperature, humidity, and water temperature [20,22]. Additionally, relative water duration data were obtained from management information to determine whether the river flowed throughout the year or only during the rainy season.

2.4. Data Analysis

L. javanica abundance was calculated as the number of individuals per 10-meter river segment to determine differences across segments. The mean and standard deviation of the weight and body size of *L. javanica* were analyzed using Microsoft Excel. The weight and body size of male and female *L. javanica* frogs were compared separately with an independent sample t-test using the IBM SPSS Statistics 24 software. They were then described and compared with literature from various sources.

Data related to the selection of microhabitat characteristics by *L. javanica* were descriptively analyzed. The spatial distribution pattern of *L. javanica* was analyzed using the variance-mean ratio method. The relationship between variance (σ^2) and mean (μ) produces three basic patterns of individual distribution: a random pattern if $\sigma^2 = \mu$, clumped pattern if $\sigma^2 > \mu$, and uniform pattern if $\sigma^2 < \mu$ [23]. Data on other frog species and tadpoles will be analyzed descriptively and are presented in tables. This study aimed to compare the presence of other frog species and tadpoles between the observation locations.

3. Results

3.1. Abundance and Morphology of *Leptophryne javanica*

Observations across the four rivers revealed that *L. javanica* was present in only three locations, with the highest abundance in Ciinjuk Springs (Table 3). At all locations where *L. javanica* was found, the standard deviation values exceeded the mean. The number of *L. javanica* individuals varied across each river and transect. In general, males ($n=68$) were more frequently encountered than females ($n=25$), except in the Cisurian Waterfall (Table 4).

Table 3. Average abundance of *L. javanica* in four rivers in Mount Ciremai National Park along a 10 m transect.

Location	Count of Transect	N total	Average abundance (ind/10 m)
Cisurian Waterfall	23	13	0.57 ± 1.74
Cilutung Waterfall	50	5	0.10 ± 0.57
Ciinjuk Spring	30	75	2.50 ± 3.09
Cilengkrang Waterfall	100	0	0

Observations started from upstream to downstream, with more *L. javanica* individuals found near the waterfalls in the Cisurian and Cilutung (Figure 2). At transect point third, we found another waterfall (Table 1) in the Cisurian Waterfall, which was part of the same water flow; *L. javanica* was only observed on the waterfall walls. In the Cilutung Waterfall, a single *L. javanica* individual was found at transect point fourth, located near the Cisurian Waterfall. At Ciinjuk Springs, *L. javanica* was more frequently encountered at transect points first and second. However, this does not suggest a preference for areas near waterfalls, as the observations at Ciinjuk Springs did not begin at a waterfall.

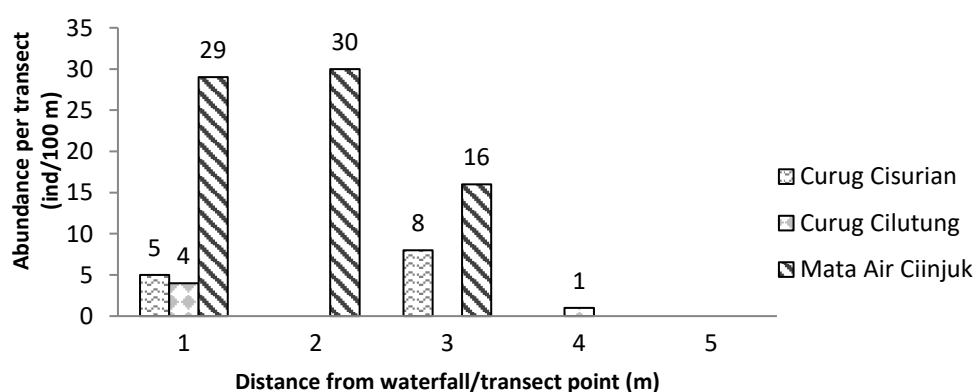


Figure 2. Comparison of *L. javanica* abundance in each river transect from upstream to downstream.

L. javanica is a small-sized frog. During the observations, the females measured between 18.75 mm and 33.90 mm in length, with weights ranging from 0.75 g to 3.50 g (Table 4). Males had body lengths of 18.00 mm and 27.00 mm, and weights of 0.75 g to 1.75 g. A t-test comparing the snout-vent length (SVL) and weight of *L. javanica* across all study locations showed a significant difference between the average SVL of females and males ($t(25.9) =$

-5.66, $P = 0.000$). A similar significant difference was found between the weights of females and males ($t(25.3) = -5.96$, $P = 0.000$).

Table 4. Comparison of the average (\bar{x}) body weight and SVL of male (M) and female (F) *L. javanica* at each observation location.

Research Locations	N		SVL (mm)		Mass (gr)	
	M	F	M	F	M	F
Cisurian Waterfall	4	9	22.58±1.30	30.11±2.63	1.13±0.25	2.77±0.78
Cilutung Waterfall	4	1	24.48±1.98	33.90	1.05±0.10	3.00
Ciinjuk Spring	60	15	20.33±1.01	23.21±3.19	1.11±0.24	1.70±0.60
Cilengkrang Waterfall	0	0	0	0	0	0

The front legs of *L. javanica* were not webbed, whereas the hind legs were (**Figure 3**). The frog body was predominantly black, with yellow spots. During the observations, only adult *L. javanica* individuals and tadpoles were found, as none of the individuals showed any signs of a tail. All individuals of *L. javanica* displayed distinct spot patterns. **Figure 4** shows only some of the pattern variations of *L. javanica*. These pattern differences can aid in identifying individual frogs, with variations including colour dominance (yellow or black), and dorsal patterns: some individuals exhibit an hourglass pattern similar to *L. borbonica*, while others form circular or diamond-shaped patterns.

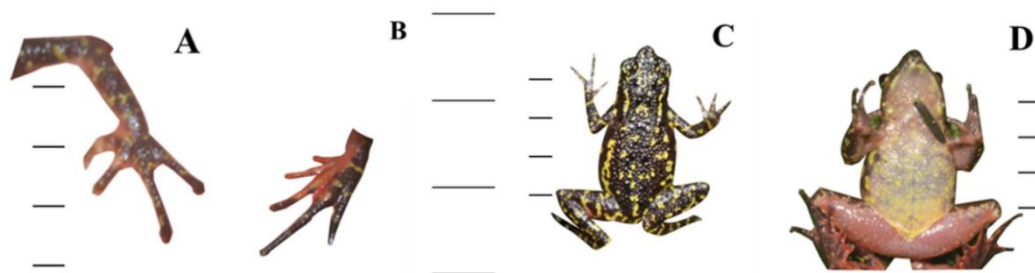


Figure 3. (A) Hand finger, (B) foot toe, (C) dorsal, and (D) ventral views of *L. javanica*. Scale bar = 5 mm.

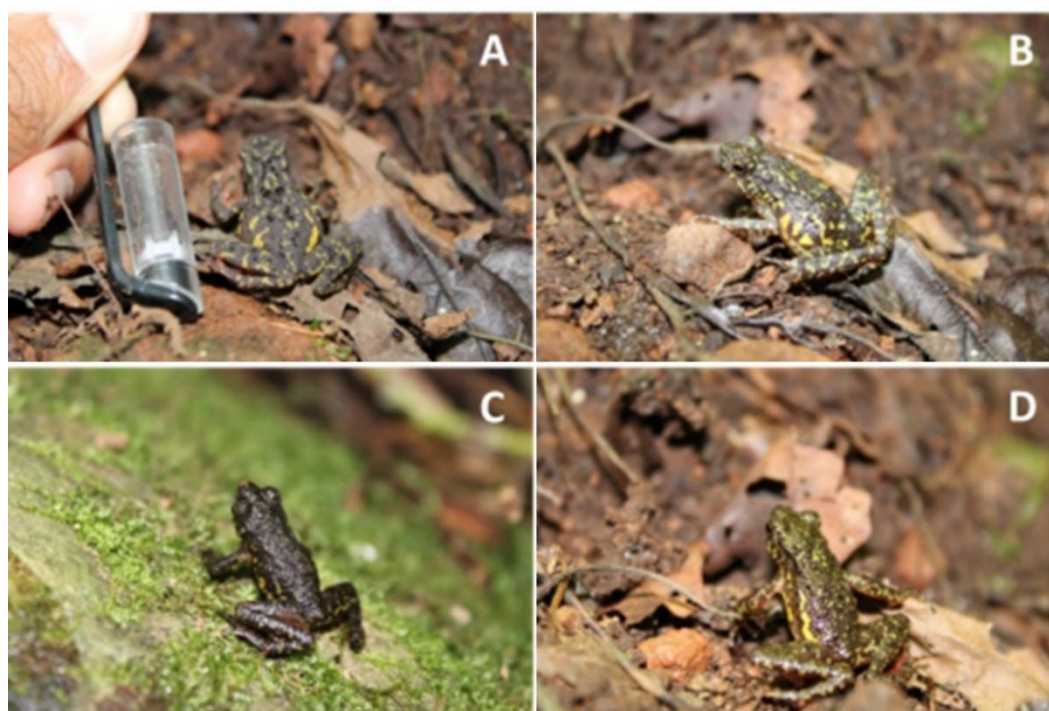


Figure 4. Various patterns of *L. javanica* found in Mount Ciremai National Park.

During the observations, pairs of *L. javanica* in the amplexus (mating) were found at Cilutung Waterfall and Ciinjuk Springs. The amplexus pair at Cilutung Waterfall was discovered at night (10:13 PM), during clear weather with a temperature of 16.9°C and relative humidity of 91%. The male had a snout-vent length (SVL) of 22.90 mm and weighed one g, while the female measured 33.90 mm in SVL and weighed three g. The mating pair at the Ciinjuk Springs was found in the afternoon (3:48 PM). The frogs were positioned on top of a rock, and a *Megophrys montana* frog was placed below the rock. The female *L. javanica* had an SVL of 26.00 mm and weighed 2.10 g, while the male had an SVL of 21.70 mm and weighed 0.90 g (Figure 5).



Figure 5. Mating pairs of *L. javanica* in Ciinjuk Spring (female below, male above).

3.2. Microhabitat Characteristics of *Leptophryne Javanica*

L. javanica frogs are generally found in rivers that have water flow throughout the year, with water temperatures ranging from 16 to 22°C. These rivers exhibit canopy cover ranging from slightly open to very dense, with river widths varying between 0.8 and 10.9 meters and a substrate of large rocks and gravel. River flow velocities were recorded between 0.34 and 0.87 meters per second. However, in this study, *L. javanica* was mostly found in relatively calm water (0.16–0.34 meters per second) at Ciinjuk Springs. Additionally, according to the observations (Table 6), *L. javanica* was found at altitudes between 1,134 and 1,291 m above sea level. During the survey, *L. javanica* was observed on large and small rocks, whether covered by moss, often clinging to the undersides of rocks, sitting on riverbanks, rocky walls at the edges of waterfalls, or submerged decaying wood.

The observations showed that *L. javanica* exhibits a group spatial distribution (Table 5). This can be observed from the proximity of the individuals found near each other. However, one individual was found to be at a considerable distance from the others.

Table 5. Spatial distribution patterns of *L. javanica* in Mount Ciremai National Park.

Research Locations	Variety (σ^2)	Average (μ)	Spatial distribution
Cisurian Waterfall	3.55	0.57	Group
Cilutung Waterfall	0.33	0.10	Group
Ciinjuk Spring	9.85	2.50	Group
Cilengkrang Waterfall	0	0	-

There are three observation sites with waterfalls: Cisirian Waterfall (approximately 7 meters high), Payung Waterfall (about 8 meters high), Cilutung Waterfall (around 10 meters high), and Cilengkrang Waterfall (approximately 12 meters high). *L. javanica* was found near the waterfalls, inhabiting crevices in waterfall walls and moss-covered rocks. The transect at Cisirian Waterfall consists of two waterfalls; the first waterfall marks the 0-point of the transect, and after 220 m, there is a second waterfall with a 10-meter flow (see Figure 1). In Figure 1, the section marked with an "X" has undergone structural changes, with concrete steps resembling pools. During the observation period, the water level in this section was relatively low (Figure 6). No *L. javanica* was found in the altered area, and only *Limnonectes kuhlii* and *Odorrana hosii* were observed.



Figure 6. Changes in the Cisirian Waterfall River: (A) before the change was made (Photo by: Kholik 2019), (B) conditions after the change was made (April 2021).

L. javanica frogs were found around Cilutung Waterfall, with one individual located 340 meters away from the waterfall, closer to Cisirian Waterfall. Cilutung Waterfall is not a tourist site, and its water is channeled to the local community through pipes. From 2018 to 2019, the community built a dam to divert water to meet their needs, preventing any water from flowing down to the Cisirian Waterfall (Figure 7). This could occur again during the dry season.



Figure 7. Condition of Cisirian Waterfall in 2018-2019 (Photo by: rbm.15).

The research site at Ciinjuk Spring originates from several flow sources that are mostly hidden by dense vegetation. In the first 30 m of the transect, the riverbanks were dominated by bamboo, with many fallen bamboos stems obstructing flow. Some participants had to be cleared to continue the survey. Ciinjuk Spring has a narrower width, shallower depth, and slower current compared to other rivers, measuring 0.8-1.2 meters wide, 1.0-3.4 cm deep, and an average current speed of 0.34 meters per second. These conditions make it an ideal habitat for *L. javanica*, allowing it to remain in the water without being swept away. *L. javanica* became more abundant after 50 meters from the starting point, with only one individual found before this distance. Beyond the 50-meter mark, they were easy to locate and often appeared close together. In some cases, two or more frogs were found on a single rock. Careful observation is needed as coloration blends with moss and stones. The thick canopy overhead allowed little sunlight to pass through, requiring flashlights or headlamps to search beneath the stones and rotting wood. The loud calls of male *L. javanica* were particularly helpful during the survey, making it easier to locate them.



Figure 8. Locations where *L. javanica* was found: (A) mossy rocks in Cisurian Waterfall, (B) under rocks in Cilutung Waterfall.

At Cilengkrang Waterfall, no *L. javanica* frogs were found, despite starting our search, similar to the previous two sites. The river flows much faster, with an average speed of 1.50 meters per second, making it quite different from the other locations we studied. Additionally, the rocks where these frogs are usually found are mostly bare moss and submerged underwater. Plants along the riverbank were thicker and often overhung water (Figure 9).



Figure 9. Condition of Cilengkrang Waterfall (not found *L. javanica*).

Cilengkrang Waterfall is a popular tourist spot that features a hot spring pool located approximately 20 m upstream of the waterfall. Visitors often relax in the pools. The hot spring water originates from a different source. Approximately 30 m before the waterfall: one from Cilengkrang Waterfall and the other carrying hot spring water (Figure 1). Hot spring water was piped into the pool. A comparison of the features of these rivers is presented in **Table 6**. As shown in the table below, the average speed of river flow at Cilengkrang waterfall is 1.50 m/s, and no *L. javanica* individuals were found. This suggests that river current speed affects the presence of *L. javanica*.

Table 6. Habitat characteristics for each observation location during days (D) and nights (N).

Variabel	Cisurian Waterfall		Cilutung Waterfall		Ciinjuk Spring		Cilengkrang Waterfall*	
	D	N	D	N	D	N	D	N
Weather	Sunny	Drizzle	Sunny	Sunny	Sunny	-	Sunny	Rainy
Temperature (°C)	21.2–22.0	17.0–20.1	18.9–20.4	16.9–19.3	20.1–23.2		21.1–26.0	19.5–21.7
Humidity (%)	84.0–85.0	85.0–89.0	83.0–90.0	83.0–91.0	74.0–80.0		62.0–86.0	81.0–89.0
Water temp. (°C)	17.5–19.0	16.0–18.0	17.5–19.0	16.0–17.5	22.0		20.0–24.0	19.0–23.0
pH	7.20–7.40		7.35		7.25		7.09	
Water clarity								Clear
Canopy density (%)		29.17–95.83		33.33–95.83	54.17–100.00			20.83–100.00
Dominant habitus		Undergrowth		Undergrowth and trees		Tress		Undergrowth
Transect length (m)		230		500		300		1,000
River width (m)		1.5–10.9		2.0–10.0		0.8–1.2		3.5–8.0
River depth (cm)		13.4–32.0		10.4–28.0		1.0–3.4		10.6–43.8
Average speed of river flow (m/s)		0.87		0.47		0.34		1.50
River dominant substrate		Rock		Rock		Rock		Rock

Note: *= *L. javanica* was not found at the location

3.3. Composition of Other Frogs and Tadpoles Found

Our observations at four different sites revealed five frog species that shared the same habitat as *L. javanica* (see Table 7). The most commonly encountered frogs were *Limnonectes kuhlii*, *Odorrana hosii*, and *Wijayarana masonii*. The numbers of other frog species varied from one site to another. Interestingly, *W. masonii* was particularly abundant at Cilengkrang Waterfall, where *L. javanica* was absent. We also found dead frogs near the hot spring pool in Cilengkrang Waterfall (Figure 10).

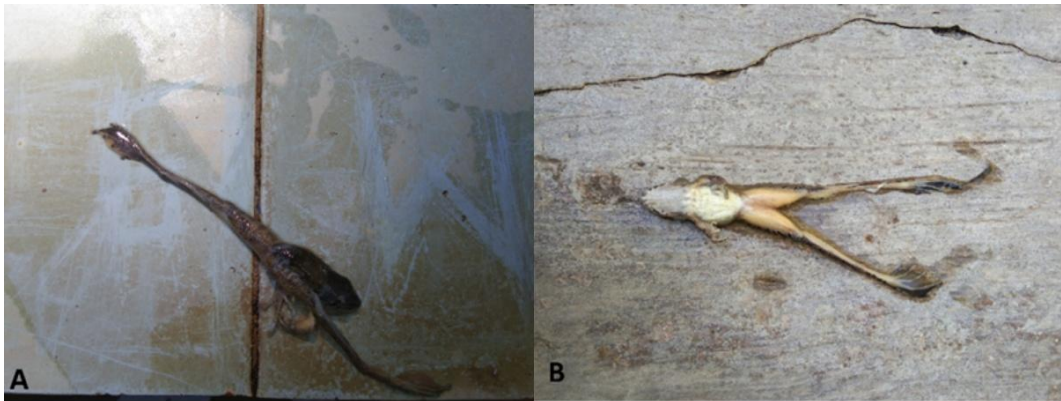


Figure 10. Other species of frogs that died in Cilengkrang Waterfall: (A) *Wijayarana masonii* and (B) unidentified.

Table 7. Species and relative abundance of frogs in four rivers in TNGC per 10 m.

Species of frogs	Cisurian	Cilutung	Ciinjuk	Cilengkrang
Bufonidae				
<i>Leptophryne javanica</i>	0.57 ± 1.74	0.10 ± 0.57	2.50 ± 3.09	0
<i>Phrynomantis asper</i>	0	0	0	0.01 ± 0.10
Dicroglossidae				
<i>Limnonectes kuhlii</i>	0.61 ± 1.17	0.02 ± 0.14	0.27 ± 1.52	0.22 ± 0.50
Megophryidae				
<i>Megophrys montana</i>	0.09 ± 0.41	0.02 ± 0.14	0.07 ± 0.25	0.07 ± 0.32
Ranidae				
<i>Odorrana hosii</i>	1.22 ± 1.38	0.7 ± 1.19	0	0.08 ± 0.31
<i>Hylarana masonii</i>	0.04 ± 0.20	0	0	0.39 ± 0.66
<i>Chalcorana chalconota</i>	0	0	0	0.02 ± 0.14
Rhacophoridae				
<i>Polypedates leucomystax</i>	0	0	0	0.01 ± 0.10
<i>Rhacophorus margaritifer</i>	0.13 ± 0.34	0.06 ± 0.24	0	0

We discovered five different tadpole species at our study sites, each at various stages of development, as defined by the Gosner stage (Table 8). These tadpoles were commonly found in calm areas along riverbanks and beneath overhanging plants (Figure 11). Interestingly, one species, *Megophrys montana*, was present at all the study sites.

Table 8. Species and count of tadpoles found according to the Gosner stage.

Locations	Species of tadpoles	Gosner Stage			Count
		24–28	29–35	>35	
Cisurian Waterfall	<i>Megophrys montana</i>	14	0	0	14
	<i>Odorrana hosii</i>	11	0	3	14
	<i>Limnonectes kuhlii</i>	4	0	2	6
Cilutung Waterfall	<i>Megophrys montana</i>	7	0	1	8
	<i>Wijayarana masonii</i>	4	0	0	4
Ciinjuk Spring	<i>Leptophryne javanica</i>	174	0	0	174
	<i>Megophrys montana</i>	20	0	1	21
	<i>Odorrana hosii</i>	4	0	0	4
Cilengkrang Waterfall		0	0	0	0



Figure 11. The location where the tadpole was found: (A) Cilutung Waterfall and (B) Ciinjuk Spring.

4. Discussion

4.1. Abundance and Morphology of *Leptophryne javanica*

The largest number of *L. javanica* were found in Ciinjuk Spring, based on our surveys at four different sites (see Table 3). Table 3 shows a wide range of values, indicating that the number of frogs found at each sampling point varied greatly. For example, at Ciinjuk Spring, the average number of frogs was 2.5/10 m, but the actual number ranged from 0 to 13 per 10 m. This pattern has also been observed for other frog species. Our findings on the *L. javanica* population differ from those of previous studies in the same area. Table 9 compares our results with those of previous studies on the Cisurian Waterfall, Cilutung Waterfall, and Ciinjuk Spring.

Table 9. Comparison of *L. javanica* findings based on previous research in the Cisurian Waterfall, Cilutung Waterfall, and Ciinjuk Spring.

Researcher	Method	Cisurian	Cilutung	Ciinjuk
Wiguna [24]	VES combined with the Capture Mark Recapture method with 3 repetitions, and the river flow length is 200 m.	35 ind	-	28 ind
Kholik [15]	VES combined with transect sampling, with unknown transect length and repetition.	102 ind	272 ind	-
Suwandi et al. [25]	VES with transect length following the river flow and without repetition.	11 ind	14 ind	-

A decrease in the number of *L. javanica* strains was found in this study. This difference could be due to several factors, including differences in observer effort and observation duration [20], the methods used, changes in habitat conditions, and increased tourism (at tourist sites: Cisurian Waterfall). The number of individuals found is likely to increase if the observation duration and observer effort increase.

L. javanica is a species that was only described in 2018 [1], and before that, it was considered the same as *L. cruentata*. In 2014, this species was found in Cisurian Waterfall and Cilutung [25]. The reason why *L. javanica* was considered the same as *L. cruentata* was because they had quite similar body patterns, only *L. cruentata* has black and red body patterns, and in some individuals, there is sometimes a combination with yellow colour, while *L. javanica* has black and yellow patterns. In addition, the pattern type of each *L. javanica* individual was different (Figure 4), which also applies to the pattern of *L. cruentata*, which includes patterns with dominant black, red, or hourglass-shaped on the dorsal [26]. The body size (SVL) of *L. cruentata* depends on its sex, that is, the SVL size of males is smaller than females [22]. Based

on the results of this study and the literature, *L. javanica* is also the same; in general, the body size (SVL) of *L. cruentata* is relatively larger than that of *L. javanica*. The SVL length of male and female *L. cruentata* ranges from 22.0–27.8 mm and 31.0–46.0 mm, respectively [26]. The SVL lengths of male and female *L. javanica* based on this study were 18.00–27.00 mm and 18.75–33.90 mm, respectively. *L. javanica* frogs seem able to perform amplexus at night or in the afternoon, although the common time for egg release is unknown. Judging by its size, the mating position of the frog is such that the male frog is on top of the female frog (Figure 5). According to [27], most frog species perform the amplexus position with the male grasping or hugging the female from behind with its front hands.

4.2. Microhabitat Characteristics of *Leptophryne javanica*

L. javanica individuals at Cisurian Waterfall were found around the waterfall, with the farthest distance from the waterfall being 20 meters. Similarly, at Payung Waterfall, which is still in the same stream, *L. javanica* was found only on the waterfall wall. Similarly, at Cilutung Waterfall, four out of five individuals were found to the left and right of the waterfall. In contrast, the other individual was found far from Cilutung Waterfall but closer to Cisurian Waterfall. Similarly, *L. cruentata*, which is the same genus as *L. javanica*, Kusri [28] reported that *L. cruentata* was also found abundantly in waterfalls and believed that waterfalls were the main habitat for *L. cruentata*. According to Iskandar [18], *L. cruentata* habitats are small rivers or slow-flowing rivers. *L. borbonica*, which is also in the same genus, is also found in clear and slow-flowing water. This is also consistent with *L. javanica*, which also prefers small rivers with calm currents, such as Ciinjuk Spring.

The Ciinjuk Spring is where most *L. javanica* was found, almost along the entire river. Generally, frogs live in forested areas to protect their bodies from dryness [18], and the denser the canopy cover, the more it helps frogs protect their bodies. This follows the conditions of Ciinjuk Spring, the habitat of *L. javanica*, which has a denser canopy cover than other locations, which is 54.17–100%. In addition, Ciinjuk Spring has a slower average river current speed (0.34 m/s) than other rivers, making this flow more preferred by *L. javanica*, considering the small size of *L. javanica* so that it can easily adapt. The results of this study differ from those of Kholik and Lucyanti [15], who stated that the habitat of *L. javanica* is generally a fast-flowing river. The spatial distribution pattern of *L. javanica* showed a clustered pattern based on the results of spatial distribution analysis. Rocks are the dominant substrate where *L. javanica* is found, and on some rocks, more than two individuals can be found. In addition, although *L. javanica* was found on different substrates, the locations were still close.

The tadpoles found in Ciinjuk Spring were suspected to be *L. javanica* tadpoles. This is because the tadpoles had a similar shape and habitat to the *L. cruentata* tadpoles found in Mount Gede Pangrango National Park (Figure 12). The *L. cruentata* tadpoles found were in mud containing wood and rotten leaves on the riverbanks, so that *L. cruentata* tadpoles could hide behind them, behind the crevices of rocks submerged in the river. Shallow waters with currents that are not too fast are usually found in *L. cruentata* tadpoles are usually found [26]. *L. javanica* tadpoles found in Ciinjuk Spring were also in shallow rivers, slow currents with substrates of sand and soil, tadpoles hid under rocks and submerged bamboo/rotten wood in the river. The color of the *L. javanica* tadpoles was solid black from the tip of the body to the tip of the tail.



Figure 12. (A) Habitat of the *L. cruentata* tadpole (Yazid [26]), (B) tadpoles of *L. javanica* in Ciinjuk Spring, and (C) tadpoles of *L. cruentata* (Yazid [26]).

Loss of habitat availability affects the survival and reproduction of organisms [29]. As in the Cisurian Waterfall, there was a river flow that was changed, and the water was dammed so that the water did not reach the Cisurian Waterfall, causing the Cisurian Waterfall to dry up (see **Figure 7**). During the study, no *L. javanica* frogs were found far from the water; the same was true in previous studies. This shows that *L. javanica* is an anuran that lives around rivers or near water to maintain body moisture [18]. The drought in Cisurian Waterfall could have caused a decline in the *L. javanica* population at this time, because *L. javanica* cannot survive under such conditions.

During the research, *L. javanica* was often found hiding among mosses. The loss of water due to drought caused the mosses to die as they could no longer perform photosynthesis. In fact, almost all living organisms rely on complex organic compounds produced through photosynthesis, including oxygen [30], which *L. javanica* also depends on. Under these drought conditions, *L. javanica*, which is usually found hiding in the crevices of waterfall walls and moss-covered rocks, could no longer inhabit these areas. This is suspected to be one of the reasons for the decline in *L. javanica* findings at Curug Cisuruan, as the species struggles to survive in such conditions.

4.3. Composition of Other Frogs and Tadpoles Found

The other frog species found at the *L. javanica* observation location were cumulatively eight (Table 7). Each location had different frog species, although some were the same. Suwandi et al. [25], conducted research at several locations in TNGC, including Cisurian Waterfall, Cilutung Waterfall, and Cilengkrang Waterfall, where this study was also located. Several species were found in this study but were not found in the study by Suwandi et al. [25], and vice versa.

The number of other frog species found in Cisurian Waterfall was greater than the research conducted by Suwandi et al. [25], the species not found were *M. montana* and *W. masonii*. Other species of frogs found in Cilutung Waterfall were four species, namely *Limnonectes kuhlii*, *M. montana*, *Odorrana hosii* and *Rhacophorus margaritifer*. While in the study of Suwandi et al. [25], seven species were found, namely *Leptophryne borbonica*, *M. montana*, *W. masonii*, *Chalcorana chalconota*, *O. hosii*, *Philautus aurifasciatus* and *R. margaritifer*. Suwandi et al. [25] found eight frog species in Cilengkrang Waterfall, surpassing the number found in the previous location. These species namely *Duttaphrynus melanotictus*, *L. kuhlii*, *Limnonectes microdiscus*, *Microhylla achatina*, *W. masonii*, *C. chalconota*, *Polypedates leucomystax* and *Rhacophorus reinwardtii*. The numbers found in this study were not significantly different among the seven species. During the research at four locations, based

on the research of Suwandi et al. [25], five other species of frogs were not found, namely, *P. aurifasciatus*, *Duttaphrynus melanotictus*, *L. microdiscus*, *M. achatina*, *R. reinwardtii*. Ciinjuk Spring had the fewest other identified frog species, with only two species found: *L. kuhlii* and *M. montana*.

The dominant species of other frogs differed at each observation location. *O. hosii* was the species with the highest findings in Cisurian Waterfall and Cilutung. According to Kusriani et al. [17], the habitat of *O. hosii* is the primary forest and can also live in logging container forests that are close to clean rivers. According to the IUCN SSC [31], the habitat of *O. hosii* is a river or tributary with constant flow and includes waterfalls. *O. hosii* was not found in Ciinjuk Spring, where the location was the habitat with the highest number of *L. javanica* findings. This is because of the shallow river and calm currents as well as the absence of waterfalls.

The most common type in Cilengkrang Waterfall is *W. Masonii* or Javan torrent frogs. This name is in accordance with the habitat of *W. masonii*, which is a river with strong currents or rapids. Kusriani et al. [17], stated that *W. masonii's* habitat is a river with a strong current, although its tadpoles have been found in rivers with a moderate current. In addition, rivers with strong currents must have clear and rocky waters.

4.4. Implications for Management

L. javanica is categorized as endangered (EN=Endangered) according to the IUCN Red List. Several efforts need to be made to ensure survival and prevent the decline of *L. javanica* populations. Due to its limited distribution, surveys must be conducted again in potential habitats for *L. javanica*. Surveys can be carried out in rivers with habitat characteristics, such as Ciinjuk Spring, as this location had the highest number of *L. javanica* findings in this study. Waterfall observations should also be conducted because *L. javanica* is often found in crevices along waterfall walls. Additionally, regular observations using the same methods should be conducted for each survey, allowing for a comparison of the observation results.

Preserving the authenticity of *L. javanica* microhabitats is also essential, especially in tourist locations such as the Cisurian Waterfall. The current condition of the Cisurian Waterfall is different from when this study was conducted, as there is now a dam in which visitors can swim. Visitors can easily approach the waterfall, posing a risk of trampling the small *L. javanica*. Therefore, education regarding *L. javanica* is necessary for visitors and managers to work together to preserve the authenticity of *L. javanica* microhabitats. Access to habitats that are not tourist locations should be restricted, only allowing researchers to maintain microhabitat conditions.

5. Conclusions

The number of *L. javanica* was found to have decreased in a previous study. The abundance of *L. javanica* in Cisurian Waterfall, Cilutung Waterfall, and Ciinjuk Spring were 0.57 ± 1.74 , 0.10 ± 0.57 , and 2.50 ± 3.09 ind/10 m, respectively. Overall, the average body size and weight of *L. javanica* were consistent across all locations, with no significant differences observed. However, a notable distinction was found between males and females, with females being larger than males in terms of size and weight. *L. javanica* was most found in habitats characterized by small rivers with slow currents, shallow waters, dense canopy cover, and minimal human disturbance. Additionally, crevices near waterfalls serve as habitats for this species.

Author Contributions

RA: Conceptualization, Methodology, Investigation, Formal Analysis, Writing – original draft; **MDK:** Supervision, Conceptualization, Methodology, Writing - Review & Editing; **AM:** Supervision, Writing - Review & Editing.

Conflicts of interest

There are no conflicts to declare.

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