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Herpetofauna distribution in different land cover types of West Java, Indonesia

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[2]Program of Environmental Science, School of Graduates, Universitas Padjadjaran. Jl. Sekeloa, Coblong, Bandung 40134, West Java, Indonesia
[3]Pusat Unggulan IPTEK Perguruan Tinggi, Centre of Environment and Sustainable Science, Directorate of Research, Community Services and Innovation, Universitas Padjadjaran. Jl. Raya Bandung-Sumedang Km. 21, Sumedang 45363, West Java, Indonesia
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Abstract. *Megantara EN, Jauhan J, Shanida SS, Husodo T, Fauzi DA, Hendrawan R, Wulandari I, Yuansah. 2022. Herpetofauna distribution in different land cover types of West Java, Indonesia. Biodiversitas 23: 2990-2999.* Herpetofauna is very sensitive and can be used as a biodiversity indicator. Herpetofauna can experience environmental stress due to agricultural activities, tourism, and other disturbances that result in habitat loss. Herpetofauna can be found on various land covers, such as natural forests and human-modified land. This study revealed species associated with natural forests, human-modified land, and both. This study aims to investigate: 1) herpetofauna distribution based on land cover types and 2) the disturbance that threatens the herpetofauna habitat in West Java. Visual Encounter Survey combination with the Auditory Encounter Survey, was applied in this study. The result of this study, the species were found in the natural forest (53 species), human-modified land (63 species), and crater (2 species). Thirty-nine species were found both in the natural forest and human-modified land. The habitat disturbance potentially threatens the species, such as land clearing (it will affect the microclimate of land cover), roadkill, infrastructure development, and tourism activities.

Keywords: Amphibian, reptile, Visual Encounter Survey

INTRODUCTION

The diversity and distribution of herpetofauna are related to any country's climatic conditions and geographical position (Ali et al. 2018). Gillespie et al. (2015) revealed that different habitat conditions have implications for differences in the herpetofauna community's composition because each species of herpetofauna responds differently to changes in existing environmental conditions. In amphibians' habitat, the first environmental filter acting on species richness is heterogeneity (Hernadez-Salinas and Ramirez-Bautista 2012; Cruz-Elizalde et al. 2016; Luja et al. 2017). Habitat heterogeneity can provide quantitative amphibian species different vegetation types associated with food resources, space, and microhabitat types (Hernadez-Salinas and Ramirez-Bautista 2012; Badillo-Saldaña et al. 2016; Luja et al. 2017). However, habitat heterogeneity can be disturbed by human activities through pollution, degradation, and land-use change (e.g., deforestation), causing cascading effects on amphibian communities such as taxonomic homogenization and species richness decline (Badillo-Saldaña et al. 2016; Luja et al. 2017; Berriozabal-Islas et al. 2018).

Herpetofauna are rarely known and little appreciated by society because of the negative feelings people have toward this animal group (Sousa et al. 2016). Amphibians and reptiles (herpetofauna) are among the most vulnerable groups of animals affected by these habitat destructions (Valencia-Aguilar et al. 2013). Herpetofauna is considered bioindicators because they are susceptible to environmental changes (Schneider et al. 2013; Saber et al. 2017). Similar to the statement of Burlibaşa and Gavrilă (2011); Carlsson and Tydén (2018); Priambodo et al. (2019), herpetofauna, especially amphibians are very sensitive to environmental changes such as pollution in waters, can be used as an indicator of biodiversity and local pressure on the environment. Herpetofauna has declined in abundance, diversity and even threatened with extinction due to rapid urbanization and intensification of agriculture, which lead to invasion of alien species and loss of habitat (Carpio et al. 2015; Cassani et al. 2015), and over-exploitation of reptiles and amphibians for consumption, industry, and pet trade (Natusch and Lyons 2012; Shaney et al. 2017).

The herpetofauna discovery is still low and has not yet described its condition entirely and thoroughly in West Java. It experiences high anthropogenic impacts both from infrastructure and tourism activities. If left further, herpetofauna species will become extinct locally because of anthropogenic factors. In South and Southeast Asia, herpetofauna research has not received much attention in terms of ecological aspects. Moreover, intensive field surveys are rarely conducted and published (Karthik et al. 2018). Herpetofauna diversity is essential because these

animals: (i) play a vital role in maintaining the sustainability of ecosystems; (ii) aid human socio-economics through utilization as tourism objects (Riyanto et al. 2019); (iii) act as pest controllers (rat and insect eaters); and (iv) provide germplasm (Cahyadi and Arifin 2019). According to Hof et al. (2011) and Cortés-Gomez et al. (2015), herpetofauna plays an essential role in the ecosystem, e.g., providing ecosystem services: pollinators, seed dispersers, and as food chain compilers, either as predators or prey.

Research on amphibians and reptiles in Java that had been conducted, e.g., Riyanto et al. (2014), Riyanto and Kurniati (2014), Riyanto et al. (2015), Hartmann et al. (2016), Kieckbusch et al. (2016), Hamidy et al. (2018), Cahyadi and Arifin (2019) and Riyanto et al. (2019). They have demonstrated that herpetofauna diversity in the region is still underestimated. Therefore, it is essential to reveal the herpetofauna species further studied regarding the management of biodiversity and the area. This study aims to investigate: 1) the herpetofauna distribution based on land cover types and 2) the disturbance that threatens the herpetofauna habitat in West Java.

MATERIALS AND METHODS

Study area

West Java Province is divided into steep mountainous regions in the South with an altitude of more than 1500 m asl, the area of the hillsides in the middle part of West Java with an altitude of 100-1500 m asl, in the North with an altitude of 0-10 m asl. West Java is located between 5˚50'-7˚50' SL and 104˚48' - 108˚48' EL. The area of West Java is 35,377.76 km^2. The Northern part of West Java Province is bordered by the Java Sea. The Southern part is bordered by the Indian Ocean. The Western region is bordered by Banten Province and DKI Jakarta, the Eastern part is bordered by Central Java Province.

The study was conducted in five locations in West Java in 2017-2018, including Cisokan in West Bandung District and Cianjur District (Februari 2017), Ciletuh in Sukabumi District (March 2017), Gunung Salak between Sukabumi and Bogor District (July 2018), Darajat in Garut District (May 2018), and Kamojang in Garut District (July 2017), West Java. The study location can be seen in Figure 1.

Cisokan referred to the development area of PLTA UCPS (Hydropower Plant Upper Cisokan Pumped Storage). Several land cover types in this location, including natural forests/remnant forests, production forests, irrigated rice fields, swidden cultivations, shrubs, mixed gardens/*talun*/agroforestry, and settlements. The site plan for the UCPS, includes the development of (a) the main construction (powerhouse, surge tank, switchyard, upstream dam, and downstream dam); (b) access road (27.5 km); (c) inundation area including upstream and downstream inundation; (d) transmission lines and quarries and potentially landslides areas (Husodo et al. 2019).

Ciletuh referred to the Ciletuh Geopark in the Ciletuh-Palabuhanratu Geopark, Ciemas Subdistrict, Sukabumi, West Java. Ciletuh Geopark shaped like an amphitheater (Wulandari et al. 2019). The land cover types found in this area including mixed gardens, natural forests, shrubs, coastal, mangroves (Wulandari et al. 2018), and settlement.

Gunung Salak, Kamojang, and Darajat referred to the PLTP (Geothermal Power Plant). The land cover types found in Gunung Salak, including natural forests, riparians, shrubs craters, and artificial ecosystems (e.g. parks). Several land cover types in Kamojang, including natural forests, production forests, and shrubs. The land cover types found in Darajat including craters, natural forests, shrubs, and mixed gardens.

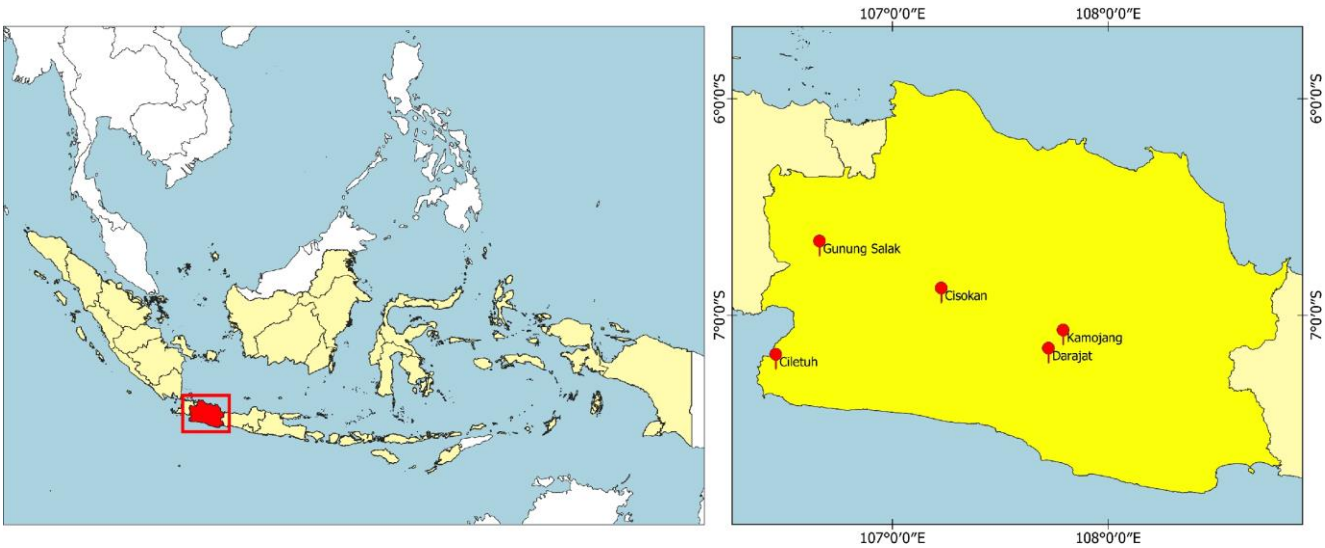

Figure 1. Study areas in West Java, Indonesia; Cisokan (48 M 746030.02 m E 9231551.58 m S); Ciletuh (48 M 661159.73 m E 9198069.84 m S); Darajat (48 M 800811.68 m E 9200549.76 m S); Kamojang (48 M 808381.73 m E 9209763.04 m S); and Gunung Salak (48 M 683756.00 m E 9255797.00 m S)

Procedures

The study's time varied, such as Cisokan was conducted for 21 days, while other locations were carried out for eight days. Herpetofauna sampling was carried out during the day and night using the time-constrained method of the Visual Encounter Survey/VES. At least two observers carry out VES by walking slowly and carefully following the existing transect paths, both footpaths or streams, to find the species on the surface of the ground, the surface of the rock, or perch on leaves and twigs. VES is carried out with a five-hour duration during the day and three hours at night on each transect. According to Boruah et al. (2016), a survey covered forest paths, woodlands, plantations, stream edges, agricultural fields, and bushes. For amphibians and nocturnal snakes, surveys were done thoroughly in all suitable habitats, such as village roads, ponds, drains, and surroundings of old buildings, bushes near streams, under rocks and logs, other water bodies, and arboreal habitats with the help of lights.

VES is combined with opportunistic exploration methods (Riyanto 2011), and auditory encounter survey/audio strip transects to detect herpetofauna, especially those fossorial or small and hidden. Herpetofauna was identified and documented in situ. Voice recording is also carried out to support the identification process, mostly small or hidden species. Vega-Trejo et al. (2013) said that voice recording is also carried out to support the identification process, especially for small or hidden species. The recording is carried out on the surrounding environmental conditions, especially threats that harm herpetofauna.

Vegetation data collection was carried out through direct observation to provide an overview of the general vegetation of an ecosystem. The data was collected qualitatively by identifying land cover types, making an inventory of dominant plant species. The identification of plant species was carried out with the guide of the book Flora of Java (van Steenis 2006). Other data collection that impacted the herpetofauna community was also carried out through direct observation, especially those related to human activities.

Data analysis

Data were analyzed qualitatively using Microsoft Excel. We recorded the number of species per location and per land cover type.

RESULTS AND DISCUSSION

The diversity of herpetofauna species in West Java found 74 species, whereas many as 24 species of amphibians and 50 species of reptiles. Because of the longer observation time in the Cisokan, the herpetofauna species were found to be more abundant than others. Maybe, all study location has a high diversity of herpetofauna, but we haven't sampled long enough to spot them all. The land cover in this study is divided into two, namely human-modified land and natural forest. Human-modified land is referred to as the settlements, infrastructured facilities, ricefields, swidden cultivations, gardens, agroforestry, plantation forest (Perum Perhutani land), and home gardens. Another land cover with specific characteristics is the crater, which is only found in Darajat, Kamojang, and Gunung Salak. However, during the observation, there were no amphibians or reptiles found in Kamojang and Gunung Salak. Fifty-three species were found in the natural forest, 63 species were found in human-modified land, and two species were found in the crater. Thirty-nine species were found both in the natural forest and human-modified land. More details about species in different land cover types in Table 1 and Figure 2.

Dominant plant species

Cisokan

Some of the rivers are in a natural forest with steep contours. In Cisokan, plants encountered in the natural forest include *Engelhardia spicata*, *Mallotus* sp., *Oreocnide rubescens*, *Trema orientalis*, *Ficus variegata*, and *Stachytarpheta jamaicensis.* Human-modified land in this location consists of settlements, shrubs, ricefields, agroforestry, production forests, ricefield, and swidden cultivation. Most of the rivers are surrounded by rice fields and shrubs. The river's characteristics range from large to small rivers, heavy water flow, large rocks and sand as river substrate. Production forests that encountered in Cisokan include teak, mahogany, and pine forests. The agroforestry was dominated by several plants, such as *Mangifera foetida*, *Arenga pinnata*, *Maesopsis eminii*, *Calliandra calothyrsus*, and *Persea americana*. The shrubs were dominated by *C. calothyrsus*, *Ageratum conyzoides*, *Imperata cylindrica*, and *Eupatorium inulifolium*.

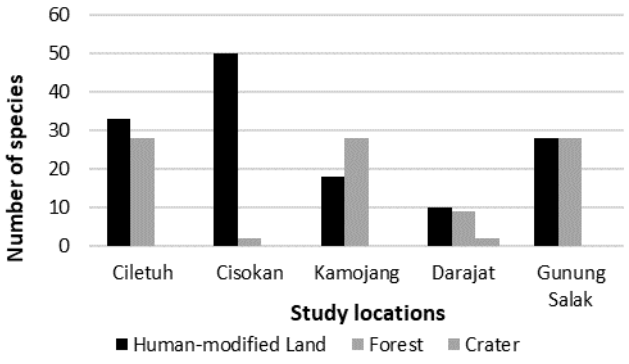

Figure 2. Number of species based on land cover types in West Java, Indonesia

Table 1. Herpetofauna in various land cover types

Species	Ciletuh		Cisokan		Kamojang		Darajat			Gn. Salak	
	HL	F	HL	F	HL	F	HL	F	C	HL	F
AMPHIBIANS											
ANURA											
Bufonidae											
Duttaphrynus melanostictus	+	+	+		+		+			+	
Ingerophrynus biporcatus			+								
Phrynoidis aspera	+	+	+							+	+
Megophryidae											
Megophrys montana[1]						+		+			+
Leptobrachium hasseltii[2]			+			+					+
Microhylidae											
Microhyla achatina[1]	+		+		+	+	+			+	+
Microhyla palmipes						+		+			+
Kaloula baleata[1]	+	+			+	+					
Dicroglossidae											
Fejervarya cancrivora	+	+	+							+	
Fejervarya limnocharis	+	+	+		+						
Limnonectes kuhlii[1]	+	+	+			+				+	+
Limnonectes macrodon	+	+	+			+				+	+
Limnonectes microdiscus			+			+				+	+
Occidozyga sumatrana			+								
Ranidae											
Amnirana nicobariensis			+		+		+			+	+
Chalcorana chalconota	+	+	+		+	+	+			+	+
Chalcorana rufipes	+	+	+		+	+	+			+	+
Huia masonii[1]			+			+		+		+	+
Odorrana hosii			+			+				+	+
Rhacophoridae											
Philautus vittiger[1]						+					+
Philautus aurifasciatus[1]						+		+			+
Polypedates leucomystax	+	+	+		+		+			+	+
Rhacophorus margaritifer[1]						+				+	+
Rhacophorus reinwardtii[1]			+			+				+	+
REPTILE											
TESTUDINES											
Trionychidae											
Dogania subplana										+	
SQUAMATA											
Agamidae											
Bronchocela cristatella		+	+		+	+				+	
Bronchocela jubata	+	+	+		+	+				+	+
Draco fimbriatus			+								
Draco volans[2]	+	+	+								
Gonocephalus chamaeleontinus			+								
Gonocephalus kuhlii						+					+
Pseudocalotes tympanistriga[1]						+					+
Gekkonidae											
Cyrtodactylus marmoratus[2]	+	+	+			+				+	+
Cyrtodactylus sp.	+	+									
Gehyra mutilata			+							+	+
Gekko gecko	+	+	+								
Hemidactylus frenatus	+	+	+		+		+			+	+
Hemidactylus garnotii	+	+									
Hemidactylus platyurus	+				+					+	+
Lacertidae											
Takydromus sexlineatus			+		+						
Scincidae											
Eutropis multifasciata	+	+	+		+		+	+	+	+	+
Lygosoma bowringii					+	+	+	+			
Sphenomorphus sanctus	+	+	+								
Varanidae											
Varanus salvator	+	+	+								
Pythonidae											
Malayopython reticulatus	+	+	+								

Colubridae											
Ahaetulla mycterizans										+	
Ahaetulla prasina	+	+	+		+	+				+	
Coelognathus flavolineatus	+										
Calamaria linnaei			+								
Calamaria lumbricoidea			+								
Calamaria modesta								+			
Calamaria schlegeli										+	
Calamaria virgulata								+			
Dendrelaphis pictus	+	+	+		+	+					
Dendrelaphis subocularis	+										
Gongylosoma baliodeirus	+		+								
Gonyosoma oxycephalum				+							
Lycodon subcinctus			+								
Ptyas carinata			+								
Ptyas korros			+								
Oligodon purpurascens			+			+					
Viperidae											
Trimeresurus puniceus			+								
Elapidae											
Calliophis bivirgatus											+
Bungarus candidus	+	+	+								
Calliophis intestinalis		+								+	
Naja sputatrix	+	+									
Ophiophagus hannah	+		+								
Natricidae											
Enhydris plumbea			+	+	+	+					
Psammodynastes pulverulentus						+					
Rhabdophis chrysargos			+			+	+	+	+		+
Rhabdophis subminiatus	+		+								
Xenochrophis trianguligerus	+	+	+							+	
Pareatidae											
Pareas carinatus			+								
Typhlopidae											
Ramphotyphlops lineatus			+								

Source: Primary Data (2017-2018); F: Natural Forest; HL: Human-modified Land; C: Crater; +: Presence

Ciletuh

Several rivers are surrounded by natural forest vegetation. It has slow to heavy water flow and is dominated by large rock substrates. River size from the large to the small river. Plant species in natural forests, including *Ficus variegata, Artocarpus elasticus, Ficus ampelas, Tetrameles nudiflora, Syzygium lineatum, Diospyros pilosanthera,* and *Dysoxylum caulostachyum*. In coastal areas, mangrove is dominated by *Ipomoea pescaprae, Sesuvium portulacastrum, Calophyllum inophyllum, Terminalia catappa, Avicennia marina, Rhizophora mucronata, Excoecaria agallocha,* and *Bruguiera gymnorrhiza*.

Human-modified land at this location consists of settlements, ricefield, agroforestry, swidden cultivation, and shrubs. Rivers that flow in the settlements have slow water flow with a substrate of soil, mud, and sand. Common species of plants are *Oryza sativa, Tectona grandis, Curcuma longa, Musa paradisiaca, Elaeis guineensis, Cocos nucifera, A. conyzoides, Pterocymbium tinctorium, Dillenia indica, Gigantochloa atroviolacea,* and *C. calothyrsus*.

Kamojang

The plants in the natural forest are dominated by *Distylium stellare, Ficus ribes, Ficus rostrata, E. spicata, Eucalyptus alba,* and *Castanopsis javanica.* Part of the natural forest is cleared as a garden (horticulture). Human-modified land referred to plantation forests (pines), shrubs, power plants and infrastructures, settlements, and agroforestry. The plants found in agroforestry included *Khaya anthotheca, Coffea arabica, Toona sureni, Cassia siamea,* and *Pinus merkusii.* Apart from *P. merkusii,* the production forest is dominated by several other plants, such as *Begonia isoptera, Curculigo capitulata, E. alba,* and *Pilea melastomoides.* The shrubs are dominated by several plants, such as *T. orientalis, C. javanica, Magnolia blumei,* and *Syzygium densiflorum.* The power plant and infrastructure areas were planted with several species, including *Albizia lebbeck, Pterocarpus indicus, Cinnamomum burmannii, P. americana,* and *Elaeocarpus ganitrus.*

Figure 3. Several species of herpetofauna; A. *Huia masonii*; B. *Leptobrachium hasseltii*; C. *Draco volans*; D. *Cyrtodactylus marmoratus*; E. *Malayopython reticulatus*; F. *Ophiophagus hannah*

Darajat

Within the natural forest, there are swamps, craters, and rivers. The swamp is directly adjacent to a natural forest, dominated by Phragmites karka, *Engelhardia serrata*, *Castanopsis argentea*, *P. merkusii*, *Schima wallichii*, *Strobilantes cernua*, and *Hedychium roxburghii*. The river's characteristics are valleys that form rocky rapids with moderate to strong water flow and clear water. The width of the river ranges from 2-5 meters. The river substrate is a mixture of rock and sand. The riverbanks are covered with shrubs and the trees at the top of the cliffs. Common flora found on riverbanks includes *Eupatorium* sp., *Ageratina riparia*, *Rubus chrysophyllus*, *Engelhardia serrata*, and *S. wallichii*. The crater's dominant plants include *Vaccinium varingifolium*, *Podocarpus neriifolius*, *Ficus deltoidea*, *S. cernua*, *Habenaria roxburghii*, *Eupatorium odoratum*, *A. riparia*, and *P. karka*.

Human-modified land at this location consists of power plants and infrastructure, and plantations. Vegetation compositions that dominate the power plant and infrastructure areas include *Cupressus macrocarpa*, *Eucalyptus* sp., *E. odoratum*, *Sonchus arvensis*, *I. cylindrica*, and *A. riparia*. Plantation found in this location includes *Eucalyptus* sp., *P. merkusii*, and *Musa acuminata*.

Gunung Salak

Small river in the natural forest has the characteristics of slow water flow. The average water depth is 20 - 50 cm, while the water depth in the river dam reaches 2 m. Clearwater with a substrate dominated by rocks. The dominant plant species around the river include *Cyathea contaminans*, *Dipteris conjugata*, *Dicranopteris linearis*, *Dinochloa scandens*, *Dichroa febrifuga*, *Clidemia hirta*, *Podocarpus neriifolius*, and *Vernonia arborea*.

The human-modified land at this location consists of power plants and infrastructure, artificial ponds, settlements, and tea plantations. The power plant and infrastructure are dominated by *Calliandra calothyrsus*, *Ficus padana*, *P. neriifolius*, *Commelina benghalensis*, *Mimosa pudica*, *Cynodon dactylon*, and *A. riparia*. The access road is dominated by *A. riparia*, *C. calothyrsus*, *S. wallichii*, and *Altingia excelsa*. The vegetation that dominates the artificial pond ecosystem includes *F. padana*, *S. wallichii*, *C. calothyrsus*, *Etlingera punicea*, *A. riparia*, and *Impatiens platypetala*. Sampling areas in settlements are focused around water bodies, such as ponds and canals. *Lantana camara*, *Melastoma malabathricum*, *C. calothyrsus*, and *Cinnamomum verum* are commonly found in residential areas. Vegetation encountered around the tea plantation includes *S. wallichii*, *C. verum*, *Delonix*

regia, C. calothyrsus, Chromolaena odorata, Amaranthus spinosus, and *C. dactylon.*

Herpetofauna in different land cover types

The number of herpetofauna compositions varied in each study location. There were differences in the herpetofauna community composition due to different vegetation communities and other river characters in each study location. These differences produce different habitat conditions and cause differences in species composition. Similar to the statement of Kurniawan et al. (2016), the abundance and number of herpetofauna species are due to environmental conditions, i.e., vegetation types, water quality, humidity, and temperature. Many species are found on human modification land. Due to the tight canopy cover and lots of litter, the moist microhabitat becomes an influential factor on herpetofauna, especially for amphibians (Wanger et al. 2011).

Species found in the crater including *Eutropis multifasciata* and *Rhabdophis chrysargos*. *Eutropis multifasciata* is associated with various land cover types, both natural forest and human-modified land. It should be noted that the crater is surrounded by natural forests, making it possible that *E. multifasciata* and *R. chrysargos* use the forest as a shelter. According to Muslim (2017), *E. multifasciata* only prey on insects.

Natural forest

The species found in the natural forest are assumed to have a low tolerance for environmental changes. The species found in the forest and human modification-land assumed that it has a high tolerance for environmental changes. Several species found only in the natural forest have a low tolerance for environmental changes because they have a specific habitat for breeding. However, forest dwellers are found in human-modified lands, such as *Huia masonii, Odorrana hosii, Limnonectes kuhlii, Leptobrachium hasseltii, Philautus vittiger*, and *Cyrtodactylus marmoratus.*

Huia masonii and *O. hosii* are species associated with natural forests and are found in heavy water flow and rocky to breed. These species are included as species with high conservation status considering the species depend on the specific habitat. *Limnonectes kuhlii* is only found in rocky streams. *Leptobrachium hasseltii* is only found in terrestrial areas with dense lower vegetation cover and resembles the forest conditions. *Philautus vittiger* is only found in stagnant waters in the forest. *Megophrys montana* and *L. hasseltii* are only found in terrestrial areas or near waters with dense lower vegetation cover in the forest. *Philautus aurifasciatus, Gonocephalus kuhlii, Pseudocalotes tympanistriga*, and *C. marmoratus* are only found in terrestrial areas in the forest. *Cyrtodactylus marmoratus* and *Cyrtodactylus* sp. are associated with forest habitats (Das 2010) and are restricted to large rocks in remnant forests.

The upstream of the river, which has mud and soil substrate, is a suitable habitat for *L. kuhlii*. The trees on the riverbank, which are found upstream and downstream of the river, can provide appropriate shelter for *P. aurifasciatus* and *Rhacophorus margaritifer*. *Limnonectes kuhlii* is also an aquatic species and likes to hide and is never encountered away from a body of water (Liem 1971).

The species commonly found in forests but located in human-modified land assumed that their habitat had been disturbed so that these species will look for a habitat that is quite humid, has a pool of water or water flow, and a shelter, such as bushes, ponds, small streams near settlements, and rice fields. Frog fertilization is generally accomplished externally outside of the female body, so water is vital during the reproduction process. Therefore, most frogs require water for embryonic and tadpole development (Riyanto and Trilaksono 2012). For example, *Microhyla achatina* needs puddles, slow-flowing streams, and pond edges (Iskandar and Mumpuni 2004).

In lizards' reproductive behavior, the presence of water is an ideal condition (Teyssier et al. 2014). *Enhydris enhydris*, often found in canals, fish ponds, rice fields, swamps, and small rivers with slow water flow, feeds on small fish and often becomes vital in pisciculture (Wiguna et al. 2009). Solsky et al. (2014) mention that a particular species whose natural habitat is terrestrial/arboreal should migrate towards a water source during spawning. Specific amphibians will be rare, or even species, of their herpetofauna when they have to live away from the water source (Vitt et al. 2009).

Human-modified land

Nineteen species were found only on human-modified land, including Ingerophrynus *biporcatus*, *Dogania subplana, Draco fimbriatus, Gonocephalus chamaeleontinus, Takydromus sexlineatus, Ahaetulla mycterizans, Coelognathus flavolineatus, Calamaria linnaei, Calamaria schlegeli,* Dendrelaphis *subocularis*, Gonyosoma *baliodeirus, Lycodon subcinctus, Ptyas korros, Trimeresurus puniceus, Ophiophagus hannah, Rhabdophis subminiatus, Pareas carinatus, Occidozyga sumatrana*, and *Ramphotyphlops lineatus*. Species encountered in the shrubs, including *M. achatina, Amnirana nicobariensis, Chalcorana rufipes, Polypedates leucomystax*, and *E. multifasciata* are species of inhabitants of open land.

Polypedates leucomystax is often found among plants or around swamps and former secondary forest felling and often approaches human habitation because insects around the lights attract it. *Fejervarya limnocharis, Fejervarya cancrivora,* and *P. leucomystax* are frogs that have experienced high anthropogenic disturbances and are associated with human habitat (Iskandar 1998). *Polypedates leucomystax* highly depends on vegetation and water (Muslim 2017). Samitra and Rozi (2020) report that *T. sexlineatus* were found in the rubber plantation that had been grassed in Lubuklinggau, making it an ideal habitat for it.

Iskandar and Mumpuni (2004) stated that *M. achatina* is located near water resources. On the other hand, *F. cancrivora* and *Occidozyga lima* live at the paddy fields and are rarely found in the river area. However, it can usually be found not far from the river (Kusrini 2013).

Locations that do not have rivers or puddles, such as plantation forests (pines), only support semi-terrestrial

amphibians' lives, such as *Duttaphrynus melanostictus*. Arboreal amphibians can tolerate this condition, such as *P. leucomystax* and *Rhacophorus reinwardtii*, which can roam relatively far from puddles as breeding grounds. Habitats that have a thick litter, such as pine forests and the meeting of lower vegetation, can provide ideal hiding places for terrestrial reptiles so that these conditions increase the level of difficulty in sampling and detecting the presence of reptiles. According to Rozi and Samitra (2020), *D. melanostictus* is a species found in the human environment, such as a dam where houses are located around the dam. Similar to the statement of Moore et al. (2015), *D. melanostictus* can be found in areas near settlements, including agricultural land.

Threats to herpetofauna

Environmental pollution

One form of environmental pollution is the use of chemicals in agricultural activities as a threat to herpetofauna. Intensive use of chemical pesticides and fertilizers in agriculture are activities that does not support herpetofauna conservation efforts. According to the Brühl et al. (2013), with life cycles that include aquatic and terrestrial phases and migration/displacement from terrestrial or arboreal areas to waters to reproduce or vice versa, making amphibians exposed to pesticides in both environments.

In terrestrial or arboreal environments, adult amphibians can be exposed to pesticides directly when farmers spray their planting commodities. This can cause death within a period of one hour to one week (Brühl et al. 2013). The negative effects of pesticides on amphibians are assumed due to their highly permeable skin properties, allowing gas, water, and electrolytes from their bodies with the surrounding environment (Lillywhite 2009; Brühl et al. 2013).

Low knowledge about herpetofauna

In general, another threat to herpetofauna's sustainability is the indifference of almost all people to herpetofauna existence. Their small size and high ability to hide make their presence difficult to detect. In the Cisokan area itself, this can be seen from the lack of knowledge from the people, indigenous people, and visitors regarding herpetofauna species in their area. Besides, most people fear snakes, and the most common action when meeting snakes is to kill them. Herpetofauna are rarely known and little appreciated by society because of the negative feelings people have toward this animal group (Sousa et al. 2016). However, not all snakes can endanger human safety. Unwittingly, this ignorance can result in the loss or extinction of the local species of herpetofauna. In contrast, our knowledge and understanding of herpetofauna in the region are still low.

Land-use change

Agricultural activities and infrastructure development often occur in West Java, which will disturb the herpetofauna habitat itself. The change and the reduction of vegetation-covered land affect the micro-climate, such as temperature and humidity, which can break the ecosystem's food chain. It will lead to the decline of herpetofauna biodiversity, and the natural habitat may be replaced by a new microhabitat having different species composition (Muslim 2017).

Infrastructure developments, such as access roads, can increase the herpetofauna community's potential danger due to being run over by vehicles. The motivation of herpetofauna's movement across the road is usually influenced by prey, predator, breeding, and hiding areas (Dodd 2009; Pike 2016). Besides, the herpetofauna community is interested in visiting and occupying areas along the road to increase body temperature, especially on cold nights. The road surface has a warmer temperature than the surrounding air (Dodd et al. 1989; Rosen and Lowe 1994). If left unattended, this can affect the decline of the herpetofauna community's local population in West Java (Langen et al. 2007).

Rapid urbanization impacts various components of the environment, including land, and is, therefore, a challenge for conserving biodiversity (Rebelo et al. 2011; Patra et al. 2018). Urbanization replaces natural habitats with infrastructures, such as houses, buildings, roads, and other impervious surfaces, resulting in changes in species composition (Vanegas-Guerrero et al. 2016; Hassan and Hassan 2019).

In conclusion, herpetofauna is found to be associated with forests, human-modified land, and both. Species that have specific habitats and occupy the forest can be used as indicators of forest conditions. However, based on the results, the species with specific habitats in the forest are also associated with human-modified land. These species are assumed because their habitat is disturbed or they have a high tolerance for the disturbance. Many human activities can potentially disrupt herpetofauna habitats, such as land clearing, which will affect the microclimate of land cover, roadkill, infrastructure development, and tourism activities. Further study is needed to what extent human activities can disrupt the herpetofauna habitat.

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REFERENCES

Ali W, Javid A, Hussain A, Bukhari SM. 2018. Diversity and habitat preferences of amphibians and reptiles in Pakistan: a review. J Asia-Pac Biodivers 11 (2): 173-187. DOI: 10.1016/j.japb.2018.01.009.

Badillo-Saldaña LM, Ramírez-Bautista A, Wilson LD. 2016. Effects of establishment of grazing areas on diversity of amphibian communities in tropical evergreen forests and mountain cloud forests of the Sierra Madre Oriental. Rev Mex Biodivers 87: 133-9. DOI: 10.1016/j.rmb.2015.09.019.

Berriozabal-Islas C, Ramírez-Bautista A, Cruz-Elizalde R, Hernández-Salinas U. 2018. Modification of landscape as promoter of change in structure and taxonomic diversity of reptile's communities: An example in tropical landscape in the central region of Mexico. Nat Conserv 28: 33-49. DOI: 10.3897/natureconservation.28.26186.

Boruah B, Das GN, Payra A, Dash SK, Pal NS, Das UP, Kar NB, Sethy J, Palei HS, Nandi D, Mishra RK, Rout SD. 2016. Diversity of herpetofauna and their conservation in and around North Orissa University Campus, Odisha, India. NeBio 7 (4): 138-145.

Brühl CA, Schmidt T, Pieper S, Alscher A. 2013. Terrestrial pesticide exposure of amphibians: An underestimated cause of global decline?. Sci Rep 3: 1135. DOI: 10.1038/srep01135.

Burlibaşa L, Gavrilă L. 2011. Amphibians as model organisms for study environmental genotoxicity. Appl Ecol Environ Res 9 (1): 1-15. DOI: 10.15666/aeer/0901_001015.

Cahyadi G, Arifin U. 2019. Potential and challenges on amphibians and reptiles research in West Java. Jurnal Biodjati 4 (2): 149-162. DOI: 10.15575/biodjati.v4i2.4820. [Indonesian]

Carlsson G, Tydén E. 2018. Development and evaluation of gene expression biomarkers for chemical pollution in common frog (*Rana temporaria*) tadpoles. Environ Sci Pollut Res 25: 33131-33139. DOI: 10.1007/s11356-018-3260-z.

Carpio AJ, Cabrera M, Tortosa FS. 2015. Evaluation of methods for estimating species richness and abundance of reptiles in olive groves. Herpetol Conserv Biol 10 (1): 54-63.

Cassani JR, Croshaw DA, Bozzo J, Brooks B, Everham III EM, Ceilley DW, Hanson D. 2015. Herpetofauna community change in multiple habitats after fifteen years in a Southwest Florida Preserve, USA. Plos One 10 (5): e0125845. DOI:10.1371/journal.pone.012584.

Cortés-Gomez AM, Ruiz-Agudelo CA, Valencia-Aguilar A, Ladle RJ. 2015. Ecological functions of neotropical amphibians and reptiles: A review. Univ Sci 20 (2): 229-245. DOI: 10.11144/Javeriana.SC20-2.efna.

Cruz-Elizalde R, Ramírez-Bautista A, Hernández-Ibarra X, Wilson LD. 2016. Species diversity of amphibians from arid and semiarid environments of the Real de Guadalcázar State Reserve, San Luis Potosí, Mexico. Nat Areas J 36: 302-9. DOI: 10.3375/043.036.0310.

Das I. 2010. A Field Guide to the Reptiles of Southeast Asia. New Holland Publishers (UK) Ltd, London.

Dodd CK Jr. 2009. Conservation and Management. In: Dodd Jr. CK (eds). Amphibian Ecology and Conservation - A Handbook of Techniques. Oxford University Press, Oxford, UK.

Dodd CK Jr. KME, Stuart JN. 1989. Reptiles on highways in North-central Alabama. USA. J Herpetol 23: 197-200. DOI: 10.2307/1564036.

Gillespie GR, Howard S, Stroud JT, Ul-Hassanah A, Campling M, Lardner B, Scroggie MP, Kusrini M. 2015. Responses of tropical forest herpetofauna to moderate anthropogenic disturbance and effects of natural habitat variation in Sulawesi, Indonesia. Biol Conserv 192: 161-73. DOI: 10.1016/j.biocon.2015.08.034.

Hamidy A, Munir M, Mumpuni, Rahmania M, Kholik AA. 2018. Detection of Cryptic taxa in the genus *Leptophryne* (Fitzinger, 1843) (Amphibia; Bufonidae) and the description of a new species from Java, Indonesia. Zootaxa 4450 (4): 427-444. DOI: 10.11646/zootaxa.4450.4.2.

Hartmann L, Mecke S, Kieckbusch M, Mader F, Kaiser H. 2016. A new species of bent-toed gecko, genus *Cyrtodactylus* Gray, 1827 (Reptilia: Squamata: Gekkonidae), from Jawa Timur Province, Java, Indonesia, with taxonomic remarks on *C. fumosus* (Müller, 1895). Zootaxa 4067 (5): 552-568. DOI: 10.11646/zootaxa.4067.5.2.

Hassan MO, Hassan YM. 2019. Effect of human activities on floristic composition and diversity of desert and urban vegetation in a new urbanized desert ecosystem. Heliyon 5: 1-10. DOI: 10.1016/j.heliyon.2019.e02283.

Hernadez-Salinas U, Ramirez-Bautista A. 2012. Diversity of amphibian communities in four vegetation types of Hidalgo State, Mexico. Open Conserv Biol J 6: 1-11. DOI: 10.2174/1874839201206010001.

Hof C, Araújo MB, Jetz W, Rahbek C. 2011. Additive threats from pathogens, climate and land-use change for global amphibian diversity. Nature 480 (7378): 516-519. DOI: 10.1038/nature10650.

Husodo T, Shanida SS, Megantara EN. 2019. Biodiversity management plan in the non-conservation area, Cisokan hydropower plan area, Cianjur, West Java, Indonesia. Biodiversitas 20 (6): 1524-1536. DOI: 10.13057/biodiv/d200606.

Iskandar DT, Mumpuni. 2004. *Microhyla achatina*. The IUCN Red List of Threatened Species 2004: e.T57873A11696337. DOI: 10.2305/IUCN.UK.2004.RLTS.T57873A11696337.en.

Iskandar DT. 1998. Amfibi Jawa dan Bali. Puslitbang Biologi - LIPI, Bogor. [Indonesian]

Karthik P, Kalaimani A, Nagarajan R. 2018. An inventory on herpetofauna with emphasis on conservation from Gingee Hills, Eastern-Ghats, Southern India. Asian J Conserv Biol 7 (1): 2-16.

Kieckbusch M, Mecke S, Hartmann L, Ehrmantraut L, O'Shea M, Kaiser H. 2016. An inconspicuous, conspicuous new species of Asian pipesnake, genus *Cylindrophis* (Reptilia: Squamata: Cylindrophiidae), from the South Coast of Jawa Tengah, Java, Indonesia, and an overview of the tangled taxonomic history of *C. ruffus* (Laurenti, 1768). Zootaxa 4093 (1): 1-25. DOI: 10.11646/zootaxa.4093.1.1.

Kurniawan N, Yanuwiadi B, Priambodo B, Maulidi A, Kurnianto AS. 2016. Various vegetation modifies the diversity of herpetofauna in Wonosobo agricultural landscape. J Environ Eng Sustain Technol 4 (2): 138-142. DOI: 10.21776/ub.jeest.2017.004.02.10.

Kusrini MD. 2013. Panduan Bergambar Identifikasi Amfibi Jawa Barat. Fakultas Kehutanan IPB & Direktorat Konservasi dan Keanekaragaman Hayati, Bogor. [Indonesian]

Langen TA, Machniak A, Crowe EK, Mangan C, Marker DF, Liddle N, Roden B. 2007. Methodologies for surveying herpetofauna mortality on rural highways. J Wildl Manag 71 (4): 1361-1368. DOI: 10.2193/2006-385.

Liem DSS. 1971. The frogs and toads of Tjibodas National Park Mt. Gede, Java, Indonesia. Philippine J Sci 100 (2): 131-161.

Lillywhite HB. 2009. Physiological Ecology: Field Methods and Perspective. Oxford University Press, London, UK.

Luja VH, López JA, Cruz-Elizalde R, Ramírez-Bautista A. 2017. Herpetofauna inside and outside from a natural protected area: The case of Reserva Estatal de la Biósfera Sierra San Juan, Nayarit, Mexico. Nat Conserv 21: 15-38. DOI: 10.3897/natureconservation.21.12875.

Moore M, Fidy JFSN, Edmonds D. 2015. The new toad in town: Distribution of the Asian toad, *Duttaphrynus melanostictus*, in the Toamasina area of eastern Madagascar. Trop Conserv Sci 8 (2): 440-455. DOI: 10.1177/194008291500800210.

Muslim T. 2017. Herpetofauna community establishment on the micro habitat as a result of land mines fragmentation in East Kalimantan, Indonesia. Biodiversitas 18 (2): 709-714. DOI: 10.13057/biodiv/d180238.

Natusch DJD, Lyons JA. 2012. Exploited for pets: The harvest and trade of amphibians and reptiles from Indonesian New Guinea. Biodivers Conserv 21 (11): 2899-2911. DOI: 10.1007/s10531-012-0345-8.

Patra S, Sahoo S, Mishra P, Mahapatra SM. 2018. Impacts of urbanization on land use/cover changes and its probable implications on local climate and groundwater level. J Urban Manag 7 (2): 70-84. DOI: 10.1016/j.jum.2018.04.006.

Pike DA. 2016. Conservation management. In: Dodd Jr CK (eds). Reptile Ecology and Conservation: A Handbook of Techniques. Oxford University Press, London.

Priambodo B, Permana H, Akhsani F, Indriwati SE, Wangkulangkul S, Lestari SR, Rohman F. 2019. Characteristic of water sources in Malang, based on the diversity, community structure, and the role of herpetofauna as bioindicator. Eur J BioSci 13 (2): 2279-2283.

Rebelo AG, Holmes PM, Dorse C, Wood J. 2011. Impacts of urbanization in a biodiversity hotspot: Conservation challenges in Metropolitan Cape Town. South Afr J Bot 77: 20-35. DOI: 10.1016/j.sajb.2010.04.006.

Riyanto A, Bauer AM, Yudha DS. 2014. A new small karts-dwelling species of *Cyrtodactylus* (Reptilia: Squamata: Gekkonidae) from Java, Indonesia. Zootaxa 3785 (4): 589-599. DOI: 10.11646/zootaxa.3785.4.7.

Riyanto A, Grismer LL, Wood PL. 2015. The Fourth Bent-Toed Gecko of the Genus *Cyrtodactylus* (Squamata: Gekkonidae) from Java,

Indonesia. Zootaxa 4059 (2): 351-363. DOI: 10.11646/zootaxa.4059.2.6.
Riyanto A, Kurniati H. 2014. Three new species of *Chiromantis* Peters 1854 (Anura: Rhacophoridae) from Indonesia. Russ J Herpetol 21 (1): 65-73. DOI: 10.30906/1026-2296-2014-21-1-65-73.
Riyanto A, Sulaeman TN, Rachman N, Chaidir DM, Trilaksono W, Farajalah A. 2019. Short communication: Herpetofauna diversity, potential ecotourism in Mount Galunggung, West Java, Indonesia. Biodiversitas 20 (4): 1173-1179. DOI: 10.13057/biodiv/d200433.
Riyanto A, Trilaksono W. 2012. Komunitas herpetofauna di lereng timur Gunung Slamet, Jawa Tengah. In: Maryanto I, Noerdjito M, Partomiharjo T (eds). Ekologi Gunung Slamet: Ekologi, Klimatologi, Biodversitas dan Dinamika Sosial. Pusat Penelitian Biologi-LIPI, Bogor & Universitas Jenderal Soedirman, Banyumas. [Indonesian]
Riyanto A. 2011. Herpetofaunal community structure and habitat associations in Gunung Ciremai National Park, West Java, Indonesia. Biodiversitas 12 (1): 38-44. DOI: 10.13057/biodiv/d120108.
Rosen PC, Lowe CH. 1994. Highway mortality of snakes in the Sonoran Desert of Southern Arizona. Biol Conserv 68: 143-148. DOI: 10.1016/0006-3207(94)90345-X.
Rozi ZF, Samitra D. 2020. Amphibians diversity in Sulap Hill and Watervang Dam, Lubuklinggau. Jurnal Biodjati 5 (1): 153-163. DOI: 10.15575/biodjati.v5i1.5340. [Indonesian]
Saber S, Tito W, Said R, Mengistou S, Alqahtani A. 2017. Amphibians as bioindicators of the health of some wetlands in Ethiopia. Egypt J Hosp Med 66: 66-73. DOI: 10.12816/0034635.
Samitra D, Rozi ZF. 2020. Short communication: The herpetofauna around human settlements in Lubuklinggau City, South Sumatra, Indonesia: Composition and diversity. Biodiversitas 21 (4): 1432-1437. DOI: 10.13057/biodiv/d210422.
Schneider L, Maher W, Green A, Vogt RC. 2013. Mercury contamination in reptiles: An emerging problem with consequences for wild life and human health. In: Kim KH, Brown RJC (eds). Mercury: Sources, Applications and Health Impacts. Nova Publishers, United States.
Shaney KJ, Wostl E, Hamidy A, Kurniawan N, Harvey MB, Smith EN. 2017. Conservation challenges regarding species status assessments in biogeographically complex regions: Examples from overexploited reptiles of Indonesia. Oryx 51 (4): 627-638. DOI: 10.1017/S0030605316000351.
Solsky M, Smolova D, Dolezalova J, Sebkova K, Vojar J. 2014. Clutch size variation in Agile frog *Rana dalmatina* on post-mining areas. Pol J Ecol 62: 679-677. DOI: 10.3161/104.062.0401.
Sousa E, Quintino V, Palhas J, Rodrigues AM, Teixeira J. 2016. Can environmental education actions change public attitudes? an example using the pond habitat and associated biodiversity. Plos One 11 (5): e0154440. DOI: 10.1371/journal.pone.0154440.
Teyssier A, Bestion E, Richard M, Cotea J. 2014. Partners' personality types and mate preferences: Predation risk matters. Behav Ecol 25 (4): 723-733. DOI: 10.1093/beheco/aru049.
Valencia-Aguilar A, Cortés-Gómez AM, Ruiz-Agudelo CA. 2013. Ecosystem services provided by amphibians and reptiles in neotropical ecosystems. Intl J Biodivers Sci Ecosyst Serv Manag 9 (3): 257-272. DOI: 10.1080/21513732.2013.821168.
van Steenis CGGJ. 2006. The Mountain Flora of Java. Pusat Penelitian Biologi-LIPI, Bogor, Indonesia.
Vanegas-Guerrero J, Fernández C, Buitrago-González W. 2016. Urban remnant forests: Are they important for herpetofaunal conservation in urban remnant forests: Are they important for herpetofaunal conservation in the Central Andes of Colombia?. Herpetol Rev 47 (2): 180-185.
Vega-Trejo R, Trejo I, Flores-Villela OA, Reynoso VH. 2013. Amphibian and reptile community structure in pristine coniferous forests: Baseline data for conservation studies. Herpetol Conserva Biol 8 (3): 622- 640.
Vitt LJ, Caldwell JP. 2009. Herpetology. 3rd ed. Academic Press, Burlington.
Wanger TC, Motzke I, Saleh S, Iskandar DT. 2011. The amphibians and reptiles of the Lore Lindu National Park area, Central Sulawesi, Indonesia. Salamandra 47 (1): 17-29.
Wiguna C, Darmono, Kapsul. 2009. Species inventory of of snake the village of Keliling Benteng Ilir, Sungai Tabuk, Banjar. Jurnal Wahana Bio 1: 33-41. [Indonesian]
Wulandari I, Hendrawan R, Husodo T, Megantara EN. 2018. Vegetation structure and composition in Ciletuh Geopark, Sukabumi, Indonesia. Asian J For 2 (2): 54-61. DOI: 10.13057/asianjfor/r020203.
Wulandari I, Shanida SS, Husodo T, Megantara EN, Tresna D. 2019. Animal utilization based on local knowledge in Ciletuh Geopark, Ciemas Subdistrict, Sukabumi, West Java, Indonesia. Biodiversitas 20 (10): 2781-2789. DOI: 10.13057/biodiv/d201001.