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A Citizen Science Survey of Urban Snakes at the Campus of Universitas Indonesia

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Abstract.—**Encounters between snakes and humans are one a common example of animal-human conflict, especially in urban areas. We evaluated the occurrence of snakes in the academic and administration facilities of the Universitas Indonesia (UI) using citizen science through a combination of surveys and public participation. The university premises accommodate a large number of diverse natural habitats within the urban forest ecosystem. Between 2017 and 2019, we gathered data on sightings of snakes within the vicinity of UI. We recorded 53 sightings of snakes representing nine species. The highly venomous Javan Spitting Cobra (*Naja sputatrix*) was the most sighted snake (36) and was encountered significantly more often than other species. Although the numbers were too small for significance testing, there was a reduction from six to zero snakes killed despite a nonsignificant increase in sightings after initiation of our awareness campaign in conjunction with our citizen science program in relocating snakes. Sightings were greater in the rainy season of November to April compared with the dry season of May to October (44 and nine, respectively), and the number of sightings have a low positive correlation with precipitation. Based on the sighting data, we identified three Snake Vigilance Zones. Our research supports the use of participatory monitoring (citizen science) for research and conservation.**

Key Words.—conservation; killing snakes; public awareness; suburbs; urban forests

Introduction

Many species of animals, plants, and other organisms are disappearing due to direct or indirect human activities with deforestation and habitat fragmentation identified as two of the major threats (Brook et al. 2003; Ferraz et al. 2003). Mobility between fragmented forested habitats results in animal mortality due to vehicular traffic (Eberhardt et al. 2013; Gustav Pettersson, unpubl. report) and the mortality rates are higher for nocturnal, ectothermic fauna such as snakes that often thermoregulate using residual heat released by road surfaces (Karunarathna et al. 2013; Mccardle and Fontenot 2016). Habitat fragmentation increases the edge effect that promotes the movement of animals across boundaries, and this increases human-wildlife conflict, a growing issue worldwide (Woodroffe et al. 2005).

Initially, human-wild animal contact mainly occurred in rural buffer areas between forest and agriculture, but as these rural lands are transformed into densely populated cities, it has been suggested that consideration should be given to returning some space to the wildlife whose habitats were altered (Kawata 2014). Due to the emerging demand for living space, especially in a country like Indonesia, humans are using agricultural land for shelters and therefore narrowing buffer areas and decreasing forest areas (Scherr and McNeely 2008). This causes the movement of natural food chains from forests to modified and even urban, ecosystems with an increased movement of predators to urban areas to be closer to their prey/food resources (Shine et al. 2007; Jadhav et al. 2018).

Management strategies that favor unpopular organisms are feasible, even in densely populated areas (Bonnet et al. 2016); however, the evidence suggests that wildlife residing in urban areas may not exhibit the same life-history traits as their rural counterparts because of adaptation to human-mediated habitats (Ditchkoff et al. 2006). The presence of snakes that are well-adapted to urban area has been identified as a new problem because much of the general public considers all snakes as dangers to be eliminated (Onyishi et al. 2020). Snakes are killed indiscriminately because most people cannot distinguish between beneficial and dangerous species; and the situation is made worse by folk myths and false assumptions about snakes (Jadhav et al. 2018). The impacts of this are unclear as snakes are also generally considered poor subjects for studies of population and community ecology because of low recapture rates and high variability in density and survival estimates (Riedle 2014). Efforts to reduce human-snake interactions have focused on preventing snakes from entering households and, if detected, translocating them to distance habitats (Chamberlain et al. 1981; Dandy et al. 2011). Translocation of nuisance or problem snakes near urban areas to far habitats, however, has had limited success and translocation potentially damages the ecological interactions in the both the residential source and destination ecosystem, and translocated snakes experience modifications in their behaviors, spatial use, and survivorship (Butler et al. 2005a; Wolfe et al. 2018).

Universitas Indonesia (UI), which is one of the most sustainable universities in Indonesia, spreads throughout 320 ha, nearly two thirds of which is covered with urban forests and lakes (Anis et al. 2018). Urban wildlife ecology and conservation is a global concern (Adams 2005) and this green urban environment provides an ideal habitat for many species of flora and fauna. Therefore, the contact between UI students or staff and wildlife is relatively high; in particular, sighting snakes inside classrooms and academic area is typical. In late 2016, a student was bitten by a Javan Spitting Cobra (*Naja sputatrix*) in the Department of Psychology building and this incident received serious attention, prompting us to conduct this study to help prevent such incidents in the future.

It had been anecdotally observed (prior to this formal study) that snake sightings appeared to be increasing annually. Therefore, the university authority and the student unions recognized that it was essential to understand the distribution pattern of the snakes on the UI campus and to increase the awareness and vigilance among the students and the staff during day-to-day tasks. Our study therefore aimed to: (1) map the snake distribution pattern at UI; (2) predict causes of snakes entering the campus; and (3) to identify snake-vigilant zones (SVZ) in which people should be especially cautious. We designed this research as a citizen science project involving the public to obtain data on how participatory monitoring can be effectively used for research.

Materials and Methods

Study area.—Of the 320 ha at the Universitas Indonesia, 53% (170 ha) is covered by green landscape of urban forests, 9% (30 ha) by lakes and aquatic ecosystems, and 5% (17 ha) by green open spaces and gardens (Fig. 1). The remaining (33%) is occupied by academic and administration buildings (Anis et al. 2018). As described by the UI development plan map from 2005, some parts of the land were formerly a rubber plantation, and the abandoned rubber vegetation is still visible today. Besides Rubber Trees (*Hevea brasiliensis*; family Euphorbiaceae), *Acacia* (Fabaceae) and Leguminoceae species are the most common plants (Pradipta et al. 2019). Flora characteristic of three major tropical rainforest biogeographic regions of Indonesia are represented in the UI urban forest: East Wallacean, West Wallacean, and Javan (Pradipta et al. 2018). Among these vegetation types, over 800 species of seed plants have been identified from the UI urban forest (Nisyawati and Mustaqim 2017).

With respect to the fauna, three species of mammals (Sheherazade et al. 2017; Unit Pelaksana Teknis Keselamatan, unpubl. report), 39 species of birds (Putri et al. 2020; Dimas H. Pradana, unpubl. report), and 15 species of reptiles (Widodo et al. 2019; Kelompok Studi Hidupan Liar Comata, unpubl. report) have been recorded within the university premises. The aquatic ecosystem of the university consists of six artificial lakes: Kenanga, Aghatis, Mahoni, Puspa, Ulin, and Salam (Anis et al. 2018; Adi et al. 2019) from which 26 species of freshwater fishes have been recorded (Sunarya Wargasasmita, unpubl. report; Mai Rohimah, unpubl. report). In addition, 10 species of amphibians (Dwi Susanto, unpubl. report) have been reported from surrounding wetlands. Most of the surveys of the wildlife of UI have been carried out in the urban forests or abandoned rubber plantations. Our study was conducted in the vicinity of the academic and administrative buildings of the university.

Survey method.—We designed this study to include the participation of the public (citizen science) to collect data on snake sightings. We used a smartphone-based Android application called UI Panic Button to collect data on snake sightings. The application was originally designed to facilitate rapid response by the university to reports by students and staff of any kind of emergency. All registered university students and staff (approximately 55,000 people) have access to this application. If there was a snake sighting within the academic and administration area of campus, the user pressed the app button and the server received an

Figure 1. The green landscape of the University of Indonesia provides ideal habitat for urban forest species. (Photograph courtesy of Univertitas Indonesia).

emergency notification along with the GPS location and the identity of the reporter. We then directly contacted the reporter to confirm the location and reached the location within 10 min of the report time. On some occasions, the snake had been killed by the time we reached the location. If we sighted the snake (alive or dead), we recorded the sighting after identifying the species. We also translocated living snakes to the urban forested area of the campus.

Awareness campaign.—Beginning in 2019, based on observations of snakes being killed during 2017 and 2018, we began an awareness campaign. We trained officers assigned to the Occupational Safety, Health, and Environment program of the university administration to carry out educational and awareness activities related to the presence of snakes and how to handle them safely. We increased awareness in two ways: by conducting educational activities in various group settings such as union meetings, monthly breakout sessions, colloquiums, social gatherings, and classroom sessions involving the university community (e.g., students, lecturers, academic and non-academic staff); and providing individual education and training on snake handling to community members (i.e., on occasions when members of the public reported the presence of snakes). We generally provided information on the morphological characteristics of the snake, where that species was potentially found, aggressive and non-aggressive behaviors, whether the snake was venomous, safe handling techniques of live snakes, and first aid procedures in case of snake bites. During the awareness program, especially when a snake had been killed on sight, we educated students of the importance of snakes in the ecosystem, their role in food chains and webs, and their benefits for control of pests such as rats and mice in surrounding human settlements.

Data collection and analysis.—We collected snake sighting data from January 2017 to December 2019, mapping the sites visually as a supplement to the GPS record. We identified areas as Snake Vigilant Zones (SVZs) if more than 10 snake sightings occurred in the same location or building. We defined each SVZ as a polygon representing locations of sightings with a 100 m radius around the sighting. We described the habitat characteristics and dominant plant species of each SVZ. Because of particular concern about human interactions with such a venomous species, we used Chi-square Tests to determine whether there was a difference between frequencies of snake sightings by species (*N. sputatrix*, versus other species) and by year. Additionally, we used a Pearson Correlation Coefficient Test to assess the relationship between snake sighting frequencies and monthly precipitation. For both tests, $\alpha = 0.05$.

Results

During the 3-y survey (January 2017 to December 2019), we recorded 53 sightings of snakes representing nine species on the UI campus. There were significantly more sightings of the highly venomous Javan Spitting Cobra than the other nine species combined (36 of 53 sightings; $\chi^2 = 17.25$, $P < 0.001$). The moderately venomous White-lipped Pit-viper (*Trimeresurus albolabris*) and the Malayan Ground Pit-viper (*Calloselasma rhodostoma*) were each sighted once. The rest of the species sighted were non-venomous or mildly venomous (Table 1).

Most of the snakes appeared to be distributed in three major clusters (Fig. 2). We defined these clusters as SVZs (Fig. 3). The highest number of sightings (17) was at the Integrated Laboratory and Research Center (ILRC). There were also five sightings from the Faculty of Economy and Business (FEB) and one sighting from Faculty of Engineering, both of which are situated next to the ILRC. Therefore, we identified the ILRC and FEB area along with the northern borders of the Faculty of Engineering (FE) as important zones for snakes. We named that area SVZ I. We identified the Wisma Makara Building (WM) and the student hostel Area (SDA) as SVZ II due to 13 sightings of *Naja sputatrix*. No other snake species was sighted in SVZ II. Although *N. sputarix* was the dominant species sighted within all SVZs, it was rarely seen outside of these three clusters (Fig. 4). We sighted 12 snakes in the three adjacent vicinities of Faculty of Law (FL), Faculty of Social and Political Sciences (FSPS), and Faculty of Psychology (FP) and we identified that area as the SVZ III. Because the rest of the 12 sightings were scattered throughout the university, we did not identify a fourth vigilance zone. Most of these non-clustered sightings (nine) were recorded in the riparian habitats surrounding by Lake Kenanga. All of the SVZs were in the areas bordering the dense urban forest of the university (Fig. 3).

The number of sightings increased between 2017 and 2019, but this increase was not significant (n = 53, $\chi^2 = 0.670$, $P = 0.715$; Fig. 5). The majority of sightings (44) were recorded in the rainy season of November to April, compared with only nine sightings during dry season of May to October and no sightings during June and August (Fig. 6). There was a positive correlation between snake sightings and precipitation ($r = 0.691$, n = 12, $P = 0.013$).

Of the 53 sightings of snakes, six involved an individual killing the snake before we reached the site. Most of the participants (including the students involved in previous killings) appeared to prefer not to kill snakes knowing they had a safe alternative and acted appreciative (pers. obs.). After we started the awareness campaign, no snakes were killed in 2019

Table 1. Species and number of sightings of snakes recorded during 2017–2019 in the vicinity of the academic and administration areas of the University of Indonesia (see Fig. 2); ILRC, Integrated Laboratory and Research Center; FEB, Faculty of Economy and Business; WM, Wisma Makara; SH, student hostel; FL, Faculty of Law; FP, Faculty of Psychology; FSPS, Faculty of Social and Political Sciences; CAP, Central Administration Park; WT, water tower; MAC, Makara Art Center; FMNS, Faculty of Mathematic and Natural Sciences; FPH, Faculty of Public Health; FE, Faculty of Engineering; US, University Stadium; – = no snakes sighted; TS = total sightings, one asterisk (*) = mildly venomous; two asterisks (**) = moderately venomous; and three asterisks (***) = highly venomous.

	Sighted locality														
Species	ILRC	FEB	WM	SH	FL	FP	FSPS	CAP	WT	MAC	FMNS	FPH	FE	US	TS
Javan Spitting Cobra*** *Naja Sputatrix*	8	5	6	2	6	3	3	–	–	1	1	–	1	–	36
Oriental Whip-snake* *Ahaetulla prasine*	–	–	–	4	–	–	–	3	–	–	–	–	–	1	8
Painted Bronzeback *Dendrelapis pictus*	3	–	–	–	–	–	–	–	–	–	–	–	–	–	3
Sunbeam Snake *Xenopeltis unicolor*	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
Indo-chinese Rat-snake *Ptyas korros*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1
White-lipped Pit-viper** *Trimeresurus albolabris*	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1
Malaysian Pit-viper** *Calloselasma rhodostoma*	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1
Red Bamboo-snake *Oreocryptophis porphyraceus*	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
Oriental Wolf-snake *Lycodon capucinus*	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1

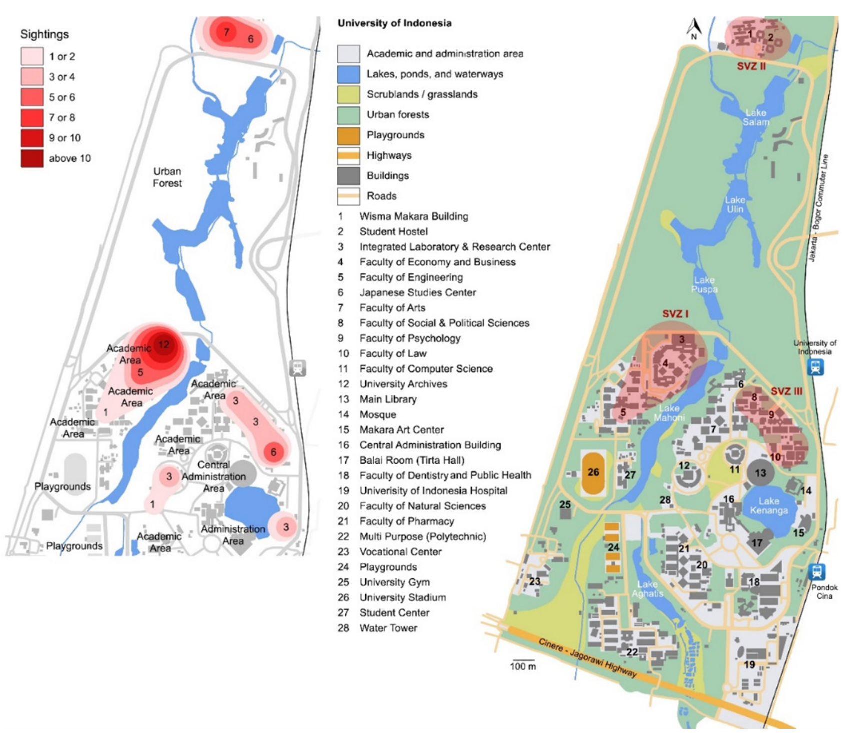

Figure 2. (Left) Areas within the University of Indonesia of three clusters of major snake sighting. (Right) Snake Vigilance Zones (SVZ#) identified within the University of Indonesia. (Maps © A.A.T. Amarasinghe).

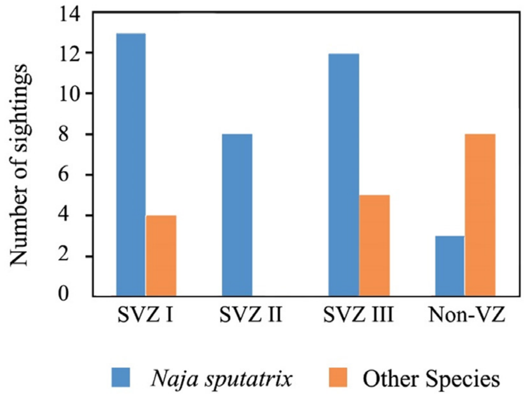

Figure 3. Number of sightings of the Javan Spitting Cobra (*Naja sputatrix*) and other snake species in each Snake Vigilance Sone (SVZ) and in Non-vigilance Zone (Non-VZ) localities within the University of Indonesia.

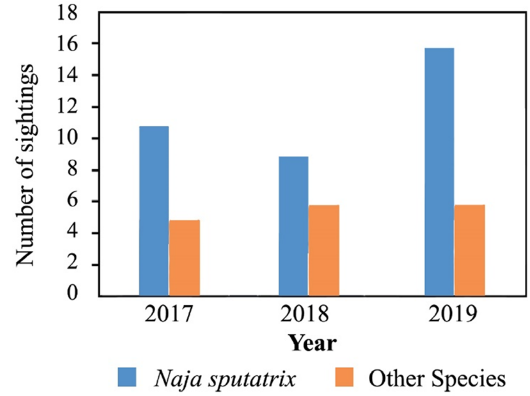

Figure 4. Number of sightings of the Javan Spitting Cobra (*Naja sputatrix*) and other snake species from 2017 to 2019 within the University of Indonesia.

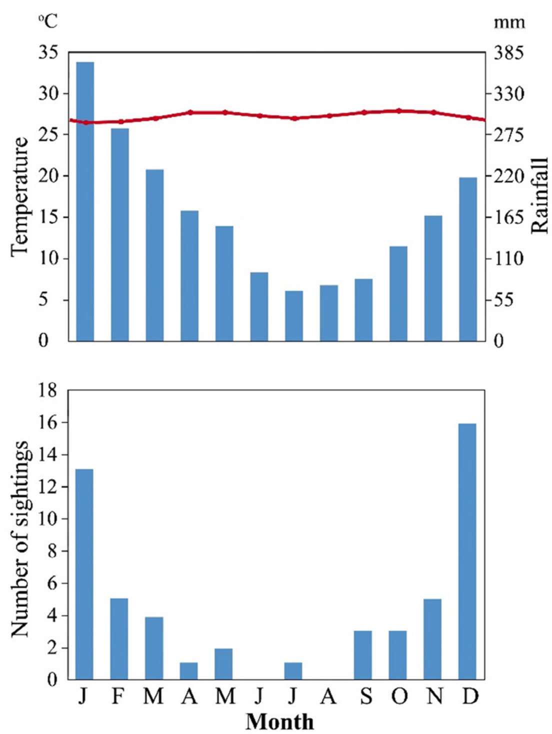

Figure 5. (Bottom) Monthly sightings of snakes during 2017–2019 compared with (Top) the average monthly rainfall (bars) and temperature (red line) during 2017–2019 at the University of Indonesia.

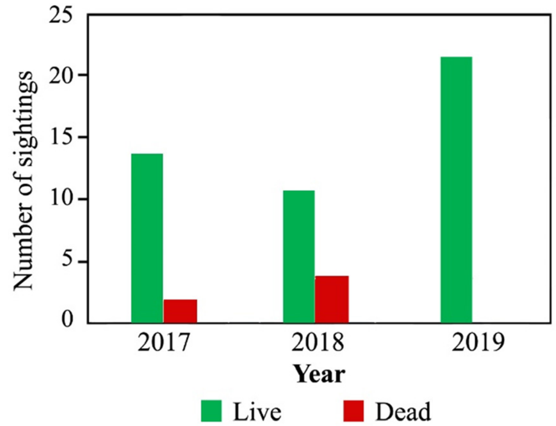

Figure 6. The number of sightings of live and dead snakes during 2017–2019 within the University of Indonesia.

(to our knowledge) despite a nonsignificant increase in sightings (Fig. 7).

Discussion

We assessed human encounters with snakes on the UI campus using data on snake sightings recorded by the users of the UI Panic Button Android application within the academic and administration portions of the UI campus. We found that most of the snake sightings occurred within or very close to buildings or academic activity areas even though all of the students and staff at the university (approximately 55,00, people) had access to this Android application. Although the public (i.e., the users of UI Panic Button) were involved in data collection by reporting the snake sighting with the GPS locality, the identification of the species was confirmed only if we sighted the snake (alive or dead).

Although the vegetative cover is well maintained in UI overall, vegetation specifically in the academic and administration areas has been highly fragmented and reduced during last 15 y (Fig. 8). The forest cover has been greatly reduced in the southeastern areas of the university due to the development of university hospital and expansion of the Faculty of Health. We did not see any snakes in the southern part of the academic or administration areas, possibly because the snakes retreated to adjacent habitats in the northern parts of the premises. In contrast, snake sightings were higher

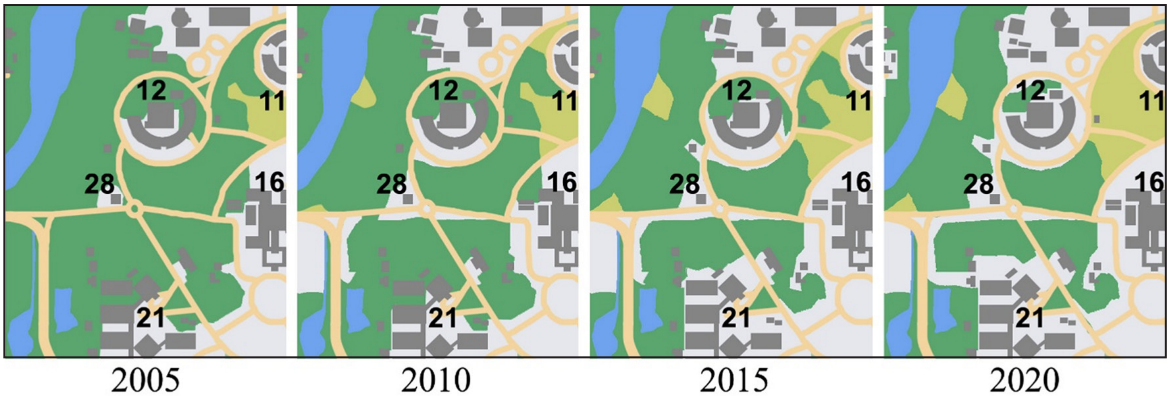

Figure 7. The urban forest fragmentation around the Central Administration building area of the University of Indonesia during 2005–2020. Numbers are building numbers (see Fig. 2).

in the northern parts of the academic area as well as the northern border of the university and this is likely due to the dense urban forest, widely spread lakes, and other waterways enclosed by dense riverine vegetation. Such aquatic ecosystems provide an ideal habitat for amphibians, one of the main prey types of these snakes (Shine 1977).

All three SVZs (I–III) that we identified were at the border of the dense urban forest in the northern part of the premises. The ecotone between the urban forest and the academic area provides an ideal habitat for both amphibians and reptiles. Many ecological studies on the edge effect showed that amphibian and reptile diversity is higher at the ecotone than in the closed forest (e.g., Schlaepfer and Gavin 2001; Wisler et al. 2008; Schneider-Maunoury et al. 2016). In a study on the spatial ecology of the Southern Copperhead (*Agkistrodon contortrix*) in urban forests in the southeastern U.S., these snakes heavily used areas bordered by roads (Carrasco-Harris 2020). Maynard et al. (2016) showed that the road-edge effect on amphibians and reptiles appeared to extend even 100 m from the road edge in Amazonian rainforest. All of the SVZs that we designated were within 100 m of the road edge.

Robillard and Johnson (2015) revealed that extensive vegetation growth has decreased potential basking sites for Eastern Massasauga Rattlesnake (*Sistrurus catenatus*) in the northeastern U.S. This could be another potential reason *Naja sputatrix* was often found on the edge of dense vegetation of urban forest. As the highest number of snake sightings was recorded from SVZ I, we further explored the geographical setting and found that a land bridge connecting the left and right banks of an elongated lake (Lake Mahoni) is located within this zone. Furthermore, this habitat provides a perfect edge of dense urban forest, an academic area, and a body of water (Lake Mahoni). We hypothesize that snakes move from the urban forest in the northern part towards riverine forests or scrublands in the southwestern part through the SVZ I. Therefore, it would be interesting to track snakes, especially *Naja sputatrix* to see snake movement patterns within the university premises. Cobras are well known to have wide home ranges and to prey mostly on mice and rats (Shine et al. 2007), and these rodents are associated with human settlements.

Based on our sightings, it seems that, despite the intense challenges posed by urbanization, *Naja sputatrix* continues to survive and even to thrive in these highly impacted landscapes. It may be the same for the gene flow of *Naja sputatrix* populations trapped on the university premises. On the other hand, the higher number of sightings of *Naja sputatrix* may represent one or a few individuals with multiple counts of sightings. Butler et al. (2005a) investigated the consequences of translocation on the spatial ecology of Tiger Snakes (*Notechis scutatus*) in an urban park in Australia and revealed that translocated snakes exhibited home ranges approximately six times larger than those of resident snakes of the same species. Therefore, due to frequent translocation, snakes, especially *Naja sputatrix* individuals in UI may maintain a larger home range than usual in natural forests.

Although we did not receive any notifications of snake sightings from the southern and southwestern parts of the university, the snake abundance in these areas could be higher than our study showed. Wetlands and dry grassy woodlands are intermixed in this part of the premises, which provides many suitable basking sites, favorable foraging opportunities, and low pressure from arboreal predators compared to the dense urban forests. The non-sightings in this part of the premises may parallel the situation in Australia, where Butler et al. (2005b) showed that snakes can be difficult to detect even when at high abundance.

As it is common to see a snake in most of the natural areas away from buildings, app users may not have felt compelled to notify us of snakes outside of the academic areas. Most of the areas in the southwestern part of the university comprise the above-mentioned wetlands, dry grassy woodlands, university stadium, and areas reserved for sports. This would be the same scenario for the non-clustered sightings recorded in between SVZ III and Lake Kenanga and mostly consists of administration buildings. There, fewer academic activities take place outside and the staffs spend their time indoors.

Night field surveys may yield higher number of sightings than reported so far. Because all the sightings of this study were reported during daytime (0800–1700) but most of the snakes are active at night, we hypothesize that the movement patterns of snakes across the academic area at night might be much higher than the results of this study. The rapid fragmentation of forest covers in this area also need to be taken into the consideration, as snakes may already avoid the degraded habitats in this region. We recorded most of the snake sightings during November to April, which is the rainy season in the area. The correlation between rain and sightings of snakes is probably due to the temporary flooding of lakes, forcing the snakes to move to academic and administration areas, which are on higher grounds. During the dry season, most of the snake movements probably occur in riparian habitats and riverine forests to which the amphibians are confined. As there is uninterrupted riparian vegetation along the waterways of lakes, we speculate that most of the snakes avoid crossing academic areas during the daytime.

Where rapid expansion of cities and urban areas has led to increased human-snake conflicts, some countries have employed snake catchers to remove and relocate snakes detected by the public in urban or rural areas (Parkin et al. 2020). During our study, due to the report of sightings of dead snakes in 2017–2018, we started encouraging students and staff of the university to become aware of and report snakes without killing them. We also trained some students to carefully relocate snakes when we received notification of snake via the Android application. Although we did not find a significant relationship between implementation of the citizen science program and snake sightings, it is encouraging that there was a nonsignificant increase in sightings accompanied by the absence of snake killings following its introduction.

Public participation in this research highlights the importance of citizen science in conservation. Such participation of citizen science has been successfully used for mitigation strategies elsewhere (e.g., in Taiwan, Yue et al. 2018). Citizen science has become increasingly important for its ability to engage large numbers of volunteers to generate observations at scales or resolutions unattainable by individual researchers (Kobori et al. 2015; Liordos et al. 2018). Here, we suggest that similar studies can be implemented at a sub- provincial level, not only to understand the snake movement patterns and obtain preliminary data of the distribution and habitat types, but also to develop hypotheses to design research with standard survey sampling methods (e.g., transects, quadrats, etc.). Information on urban sites where snakes are more likely to be found is important not only for conservation, but also to help local citizens better understand and live among snakes (França and França 2019).

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