

Citizen Science Program for Critically Endangered Primates: A Case Study from Singapore

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Abstract: Raffles’ banded langur (*Presbytis femoralis*) is one of three species of non-human primates in Singapore. With only 67 individuals left, it is listed as locally Critically Endangered. Due to its elusive nature, arboreality, and small population size, public awareness of its presence in Singapore is low, and this hampers conservation efforts. We thus initiated a citizen science project on Raffles’ banded langurs in Singapore. Citizen scientists carried out field observations during weekends (08:00–11:00 and 15:30–18:30, with 96 survey assignments per survey cycle of 24 weeks). Overall 143 people were recruited to take part in the surveys. They completed 631 survey assignments from August 2016 to October 2019 (3.5 years), with an average volunteer retention rate of 38%, i.e., 38% volunteers continued to the next cycle while 62% were new volunteers. A total of 157 sightings of Raffles’ banded langurs were recorded, amounting to a 24.9% encounter rate, i.e., one sighting for every four survey assignments. On average, 65.8% volunteers saw the langurs at least once. Using sighting locations, group demographics, high-resolution photographs from citizen scientists, and data collected by researchers, we confirmed five groups of langurs comprising 34 individuals along the survey route—over half of the langur population in Singapore. With data from observations of the langurs’ use of roads to travel between forest fragments, the authorities were able to plan and construct a rope bridge to facilitate their safe crossing. We consider this citizen science project a success because of the high rate of observations made of these critically endangered and infrequently seen wild primates. Most importantly, this project demonstrates a successful partnership between the public, a government agency, non-governmental organizations, and educational and private institutions.

Key words: Citizen science, Colobinae, Critically Endangered, Singapore, Multi-stakeholder partnership

Introduction

Singapore is home to three species of non-human primates: the Sunda slow loris (*Nycticebus coucang*), the long-tailed macaque (*Macaca fascicularis fascicularis*), and Raffles’ banded langur (*Presbytis femoralis*). While the population size of the Sunda slow loris in Singapore is unknown, it is considered locally Critically Endangered (Lim *et al.* 2008) and, overall, it is classified as Vulnerable (Nekaris *et al.*, 2020). The population of the long-tailed macaque in Singapore is estimated at 1,810–2,166 (Riley *et al.* 2015), and it is ranked globally as Vulnerable (Eudey *et al.* 2020). Raffles’ banded langur is locally Critically Endangered (Lim *et al.* 2008). In the past, it was considered to comprise three subspecies (Ang and Boonratana 2020), with the nominate form occurring in Singapore. A recent genetic study, however, has revealed that each is a distinct

species, and Ang *et al.* (2020a) argued that *femoralis* is Critically Endangered throughout its range. Since December 2019, two non-native dusky langurs (*Trachypithecus obscurus*) have been observed in the forests in Singapore. It was believed that they swam across the Johor Strait and/or traveled on the Johor-Singapore Causeway from Malaysia (Ang *et al.* 2020b).

The Raffles’ Banded Langur Working Group (<www.facebook.com/RBLWG>) was formed in August 2016 through the partnership of various organizations and agencies in Singapore and Malaysia, including Wildlife Reserves Singapore, the National Parks Board (Singapore), the Jane Goodall Institute (Singapore), the National University of Singapore, the Nature Society (Singapore), the Malaysian Nature Society, Johor, the Malaysian Primatological Society and the Universiti Sains Malaysia. This multi-stakeholder partnership is tasked to implement the species action plan

for the long-term protection and recovery of the Raffles' banded langur (Ang *et al.* 2016). Two of the issues identified that threaten the survival of the taxon were the lack of awareness of its existence in Singapore and the confusion and misidentification between Raffles' banded langur and another, more common, langur species, the dusky langur (*T. obscurus*) in Malaysia, where the two are sympatric. A key step, therefore, was to raise public awareness and understanding of Raffles' banded langur in both countries in order to promote its conservation.

Citizen science involves public voluntary participation to monitor and collect data on wild animals, plants, habitats or other key environmental markers (Kobori *et al.* 2016). Citizen science is also an opportunity to empower and inspire the general public to work together with scientists to expand shared knowledge and explore solutions (Bonney *et al.* 2016). An example of a large-scale, worldwide citizen science initiative is called Bioblitz, started in 1996 by Susan Rudy, a National Park Service employee in Washington, DC (Baker *et al.* 2014). Bioblitz is an organized event-competition where volunteers come together in cities across the globe to identify as many plant and animal species as possible within a short period of time (Baker *et al.* 2014). In 2019, more than 150 cities motivated more than 34,000 people to upload over 920,000 observations of nature to iNaturalist in the four days of the Bioblitz-style City Nature Challenge.

In Asia, a number of citizen science projects covering plants, animals, habitats or ecosystems have begun to gain traction in the last few years. The involvement of citizen scientists for projects monitoring wild animals has occurred mainly in China, India, and Singapore, where the majority were focused on birds (Table 1). In India, an on-going initiative called the "Hornbill Watch" was set up to gather the general public and birdwatchers to document the distribution of nine hornbill species in the country and to identify sites for hornbill protection. Between June 2014 and February 2017, 430 citizen scientists uploaded 938 records to the project's website (including sightings made as far back as 2000). The collated distribution data of the hornbills placed an emphasis on the importance of green, open spaces for hornbill survival in an urban environment (Datta 2018).

Citizen science monitoring of primates in Asia is still limited, with just three known organized initiatives targeting the gray slender loris (*Loris lydekkerianus*) in Bangalore, India, the Bornean orangutan (*Pongo pygmaeus*) in Sabah, Malaysia (see Orangutan Nest Watch, undated), and gibbons (*Hylobates agilis*, *H. lar* and *Symphalangus syndactylus*) in Peninsular Malaysia (Md. Rameli *et al.* 2020). These initiatives tapped into social media platforms and online portals to gather information about their target species. The Urban Slender Loris Project sought input from the public regarding sightings—dates, number of individuals, distribution, habitat type—and trade of gray slender lorises in the city through

Table 1. Citizen science projects on wild animals in Asia.

Class (Order)	Project Name/Species	Location	Duration	Reference
Aves	China Coastal Waterbird Count	China	2005 to present	< www.chinabirdnet.org/document/waterbirdreport_10to11.pdf >
Aves	Bird Count India	India	2019 to present	< https://birdcount.in/ >
Aves	Garden Bird Watch	Singapore	2019 to present	< www.nparks.gov.sg/biodiversity/community-in-nature-initiative/nparks-garden-bird-watch >
Aves (Bucerotiformes)	Hornbill Watch	India	2014 to present	Datta 2018 and < www.natureasia.com/en/nindia/article/10.1038/nindia.2018.142 >
Aves (Pelecaniformes)	Heron Watch	Singapore	2018 to present	< www.nparks.gov.sg/biodiversity/community-in-nature-initiative/nparks-heron-watch >
Amphibia (Anura)	Frog Watch	India	2014 to present	< https://indiabiodiversity.org/group/frog_watch/about >
Insecta (Lepidoptera)	Butterfly Watch	Singapore	2017 to present	< www.nparks.gov.sg/biodiversity/community-in-nature-initiative/nparks-butterfly-watch >
Insecta (Odonata)	Dragonfly Watch	Singapore	2017 to present	< www.nparks.gov.sg/biodiversity/community-in-nature-initiative/nparks-dragonfly-watch >
Mammalia (Primates)	Urban Slender Loris Project	India	Unknown to present	< https://docs.google.com/forms/d/e/1FAIpQLSdsMFkqE_cPojOqtJmBrF1bl3qHKkxUSZjvIhbPnApX19a-jg/viewform?fbclid=IwAR2RIHWRXn3g5U_52ltgmzccQ1pvvA11UW3tJP7OkK7VUjRZg7wacVZ1Hsw >
Mammalia (Primates)	Orangutan Nest Watch	Malaysia	Unknown to present	< www.zooniverse.org/projects/sol-dot-milne/orangutan-nest-watch >
Mammalia (Primates)	Small Apes	Malaysia	2017 to 2019	Md.-Rameli <i>et al.</i> (2020) and < https://onlinelibrary.wiley.com/doi/abs/10.1002/ajp.23112 >

an online questionnaire promoted via Facebook. In Peninsular Malaysia, a primate research team from the Universiti Sains Malaysia searched for reports of gibbon observations on various social media platforms and also solicited such information from citizen scientists (for example, birders and hikers), who might have seen them during their activities. The team found that social media observations were useful for assessing the distribution of gibbons in Peninsular Malaysia and were valuable in adding new information about their occurrence; i.e., social media observations indicated the presence of gibbons in at least six habitats where they had not been previously reported (Md. Rameli *et al.* 2020).

Apart from using social media resources and online portals as described above, there were only a few projects involving citizen scientists carrying out field observations of primates (Table 2). The Fundación Pro-Conservación de los Primates Panameños (FCPP) is a non-profit organization, which conducts annual primate population censuses in the various reserves and fragmented forests of Panama, especially of taxa which are poorly studied or Critically Endangered, such as the Azuero spider monkey (*Ateles geoffroyi azuerensis*). The FCPP recruits students from the University of Panama and provides them with basic training before the commencement of field surveys (see FCCP 2019).

There is still a lack of understanding of how citizen science programs can be organized and implemented by the

general public in the field for the study and conservation of highly threatened primates. Here, we evaluate our first citizen science field monitoring program on the Critically Endangered Raffles' banded langurs in Singapore. We track the progress in volunteer participation and assess the data collected by citizen scientists. We discuss the structure, implementation, and feasibility of an outdoor citizen science program for a critically endangered primate, which could be replicated for other threatened primates in Asia and around the world.

Methods

We began a citizen science program for the Raffles' banded langur in Singapore with a training workshop for volunteers on 24 July 2016. The volunteer recruitment drive was publicized using social media platforms such as Facebook, and via e-mail to networks of tertiary institutions, non-governmental organizations, and relevant government agencies in Singapore. During the 1.5-hour training session, we provided background information on the Raffles' banded langur and introduced the objectives and survey protocols of the citizen science program.

The first round of citizen science surveys began three weeks after the training workshop. Each round of surveys was over a period of 24 weeks (six months) and occurred only during the weekends. Before the end of each 24-week

Table 2. Citizen science projects on primates around the world.

Species	Project name	Location	Duration	Reference
Primates in Brazil	SISS-Geo	Brazil	2014 to 2018	Chame <i>et al.</i> (2019) < https://doi.org/10.1007/s41666-019-00055-2 >
Chimpanzees	Chimp&See	Africa	2015 to 2017	< www.mpg.de/9187456/chimps-see-citizen-science >
Vervet monkey	Vervet Monkeys	South Africa	November 2016	Patterson <i>et al.</i> (2017) < https://doi.org/10.1007/s11252-016-0619-0 >
Central American Spider Monkey; Yucatán Black Howler Monkey	Primate Watch Belize	Belize	2018 to present	< https://mybeautifulbelize.com/citizen-input-through-primate-watch-belize-helps-monitor-monkey-populations/ >
Primates	Project Noah	Global	2010 to present	< www.projectnoah.org/organisms?search=primates >
Bornean Orangutan	Orangutan Nest Watch	Malaysia	Unknown to present	< www.zooniverse.org/projects/sol-dot-milne/orangutan-nest-watch >
Small Apes	-	Malaysia	2017 to 2019	Md.-Rameli <i>et al.</i> (2020) and < https://onlinelibrary.wiley.com/doi/abs/10.1002/ajp.23112 >
Rhesus Macaque	Monkey Health Explorer	Puerto Rico	Unknown to present	< www.zooniverse.org/projects/mbarrierz/monkey-health-explorer >
Gray slender loris	Urban Slender Loris Project	India	Unknown to present	< https://docs.google.com/forms/d/e/1FAIpQLSdsMFkqE_cPjOqtJmBrF1b13qHKkx-USZjvllhbPnApX19a-jg/viewform?fbclid=IwAR2RIHWRXn3g5U_52ltgmzccQ1pvyA1IUW3tJP7OkK7VUjRZg7wacVZ1Hsw >
Azuero Howler Monkey; Azuero Spider Monkey	Fundación Pro-Conservación de los Primates Panameños (FCPP)	Panama	2001 to present	< www.fcprimatespanama.org/nosotros.html >

round, we conducted a training workshop to recruit volunteers for the next round as well as to share the findings of the current survey.

A 4-km survey route (Fig. 1) along public trails at the Lower Peirce Reservoir Park and along Old Upper Thomson Road (two-lane; 7-m wide) at the edge of the Central Catchment Nature Reserve was selected as it was 1) an accessible path with minimal difficulty and 2) among the areas where the langurs (herein referring only to Raffles' banded langurs) could be observed. On Saturdays and Sundays, survey assignments were 08:00–11:00 and 15:30–18:30, when the langurs were most active (Ang *et al.* 2010), for a total of 96 assignments in each 24-week round. Each survey assignment required a minimum of two volunteers to ensure reliability of data collection and for safety and allowed a maximum of three volunteers, so as to minimize disturbance to the wildlife. Citizen scientists began the survey at the same time, covering the route in a single direction. The volunteers were taught to carry out the surveys at a slow walking speed (*c.* 25 m/min) and to keep their voices down. Volunteers were also advised to maintain a distance of at least 3 m from the langurs. Each volunteer was required to commit

to six survey assignments, unless otherwise due to inclement weather, such that a minimum of 32 volunteers and a maximum of 48 volunteers were necessary for each round of surveys. There were no age restrictions, but individuals who were less than 18 years old had to be accompanied by a parent or guardian. A Google Sheet of the schedule was shared with all citizen scientists before the commencement of surveys so that they could indicate their availability. A reminder e-mail with the contact details of their survey partner(s) was sent a few days before their scheduled survey. We did not participate in the surveys.

Data collection was focused on the langurs, including date and time of sighting, location, number of individuals, age/sex and behavior. We encouraged citizen scientists to provide descriptive accounts, specifically looking out for observations of traveling (*i.e.*, moving), feeding, playing, and resting, and also noting other behaviors. We then counted the number of instances of each of the above four categories to evaluate the behaviors most commonly seen. For location, citizen scientists were taught to use the nearest lamppost number (distance between two lampposts is *c.* 20 m) to mark the location of langur sightings along Old

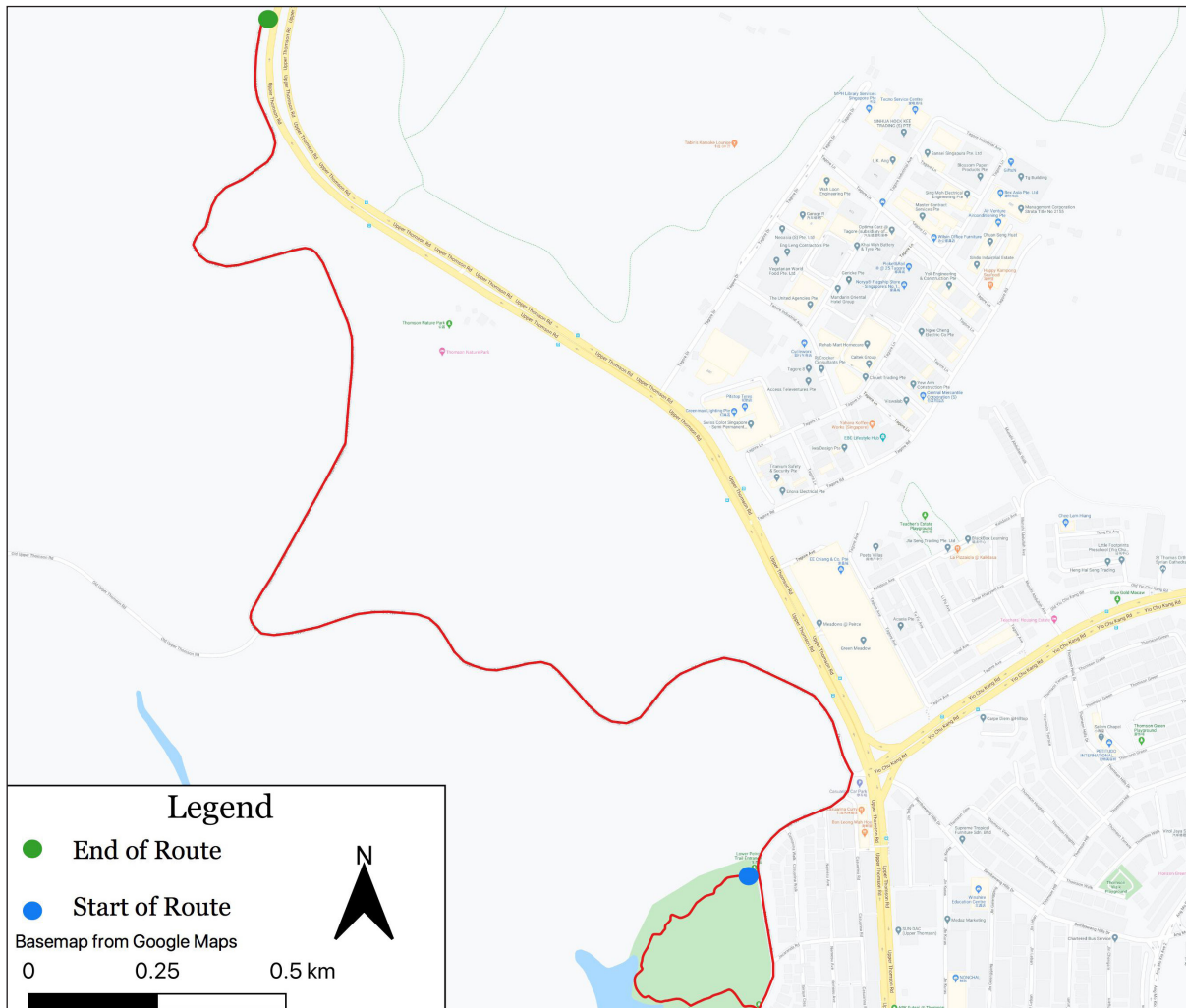


Figure 1. Map of 4-km survey route within Lower Peirce Reservoir Park and along Old Upper Thomson Road. Map created by Eddy Kwoh.

Table 3. Volunteer recruitment over seven rounds of citizen science monitoring program.

Citizen science survey period	# of volunteers*	# of new volunteers**	Volunteer retention rate	Survey assignments completed***
1 st (13 August 2016 – 22 January 2017)	31	31	N/A	86 (89.6 %)
2 nd (28 January – 9 July 2017)	31	25	19.4 %	94 (97.9 %)
3 rd (15 July- 24 December 2017)	35	25	32.3 %	90 (93.8 %)
4 th (30 December 2017 – 10 June 2018)	40	26	40.0 %	87 (90.6 %)
5 th (16 June – 25 November 2018)	38	18	50.0 %	90 (93.8 %)
6 th (1 December 2018 – 12 May 2019)	41	23	47.4 %	91 (94.8 %)
7 th (18 May – 27 October 2019)	29	12	41.5 %	93 (96.9 %)
Average	35		38.4%	90.1% (93.9%)
Total	245			631

*Number of volunteers who completed at least four assignments during each survey period; **Number of newly-recruited volunteers who had not participated in the immediate past survey period; ***Each survey period comprises 96 survey assignments. Survey assignments were not completed or cancelled due to inclement weather (rain).

Upper Thomson Road and to use an approximate distance into the trail for observations within Lower Peirce Reservoir Park. They were also encouraged to record the coordinates on any mapping application on their phone if signal/reception was available, and to bring a pair of binoculars (10×42 recommended) and/or camera, though this was not mandatory. Google Sheet and SGBioAtlas (<<https://biome.nparks.gov.sg/>>) were used for data recording. Only registered volunteers were given access. Photographs and videos of langurs sighted were e-mailed to us at the end of each survey. Incidental records on other wildlife (such as long-tailed macaques and other vertebrates) were also noted. All activities in the citizen science program were voluntary, and no monetary compensation was provided. The age, nationality, and occupational status of the citizen scientists were collected, though not mandatory.

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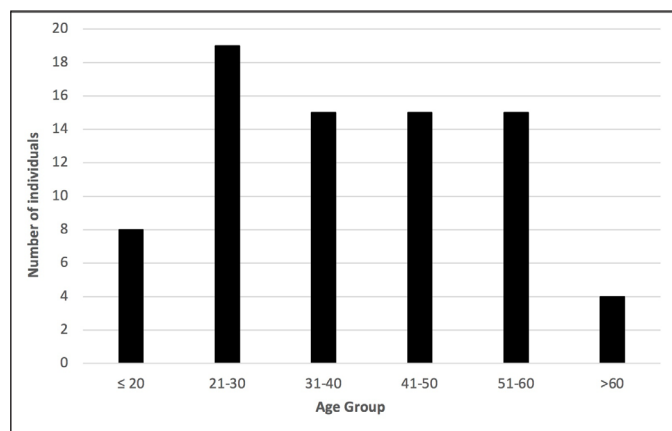


Figure 2a. Age demographics of citizen scientists when they first participated in the survey (N = 76).

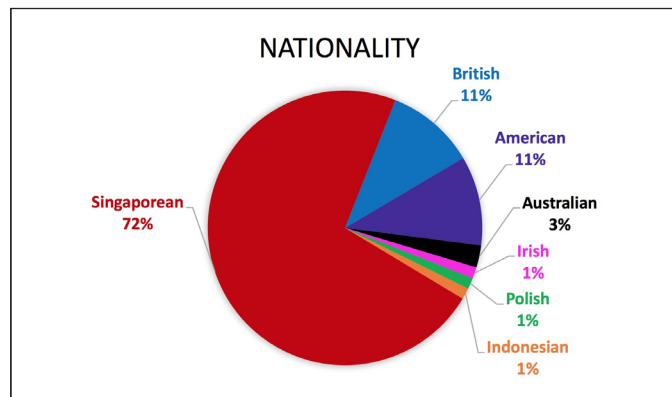


Figure 2b. Nationalities of citizen scientists (N = 76).

Results

Seven training workshops were held, the first on 24 July 2016 and the last, reported here, on 12 May 2019. They were attended by 593 people (average of 84 attendees at each workshop). On average, they first found out about the workshops through e-mail (33.5%), word of mouth (30.1%), social media (25.3%) or others (11.0%) (see Appendix). Seven continuous rounds of citizen science surveys were completed between 13 August 2016 and 27 October 2019. Nearly 90% of the survey assignments in each round were completed; those that were not completed or canceled were due to rain (Table 3). A total of 143 people were recruited, with an average of 35 volunteers in each round. During each round, the volunteers recruited were mostly new volunteers, with an average retention rate of 38%, i.e., 38% volunteers continued to the next round while 62% were new volunteers (Table 3).

Of 143 volunteers, 76 provided information on age, nationality, and occupational status for when they first participated in the citizen science project. There was a fairly even representation of participants from different age classes, except for those >60 years old or ≤20 years old (Fig. 2a). Most of the participants (72%) were Singaporean (Fig. 2b), and a majority (87%) were either working adults or students (Fig. 2c).

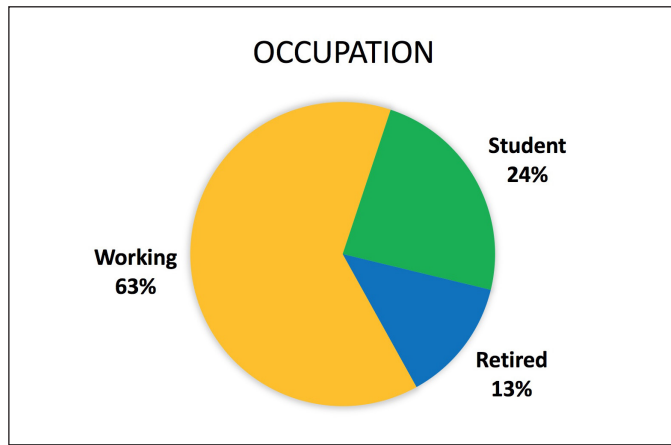


Figure 2c. Occupation status of citizen scientists (N = 76).

For each of the seven survey periods, more than half of the volunteers saw langurs, with an average of 65.8% who encountered them at least once (Table 4). A total of 157 sightings of langurs were recorded, which amounted to an average of 22.4 sightings during each round (i.e., 23.4% encounter rate) (Table 4). Five groups of langurs were detected along the survey route, totalling 34 individuals. This information was cross-checked and verified by the first two authors who carried out weekday surveys in the same area during the same period of 3.5 years (Ang *et al.* 2016). Actual coordinates of sightings are withheld to minimize disturbance to the animals and habitat.

The most commonly observed behavior was traveling, followed by feeding, resting, and playing (Fig. 3). For traveling, citizen scientists noted that the langurs were either moving away from observers or moving in the tree canopy. Of the feeding instances, citizen scientists were only able

to identify three plants, namely Rambutan (*Nephelium lappaceum*; fruits – once), rubber tree (*Hevea brasiliensis*; leaves – twice), and the African Tulip tree (*Spathodea campanulata*; flowers – once). The langurs were also seen feeding on figs, but citizen scientists could not identify the species. Other behaviors observed included urinating (twice), defecating (once), and mating (once).

We noticed tree pruning by the relevant authorities along the Old Upper Thomson Road on 20 October 2017, which led to a loss of canopy connectivity at a langur crossing hotspot. Two days later, and on two separate occasions on 5 November 2017 and 24 March 2018, citizen scientists reported three sightings of langurs descending from the trees to the road to cross between the forest fragments at the exact location where the trees had been trimmed.

Discussion

Our project constitutes one of the first long-term, organized outdoor citizen science field surveys on a locally critically endangered primate species. As compared to soliciting observations online (for example, Md. Rameli *et al.* 2020 for gibbons in Malaysia) or seeking participation from the public using an online questionnaire (for example, the Urban Slender Loris Project in India), we elected to run a program to regularly recruit volunteers who would carry out field surveys on the Critically Endangered Raffles’ banded langur in Singapore. This approach was designed to raise public awareness about the biology and threats of this target species and simultaneously gather vital data for research and conservation. Even though we did not quantitatively analyze the impact of the citizen science program, we reached out to hundreds of participants through the training workshops

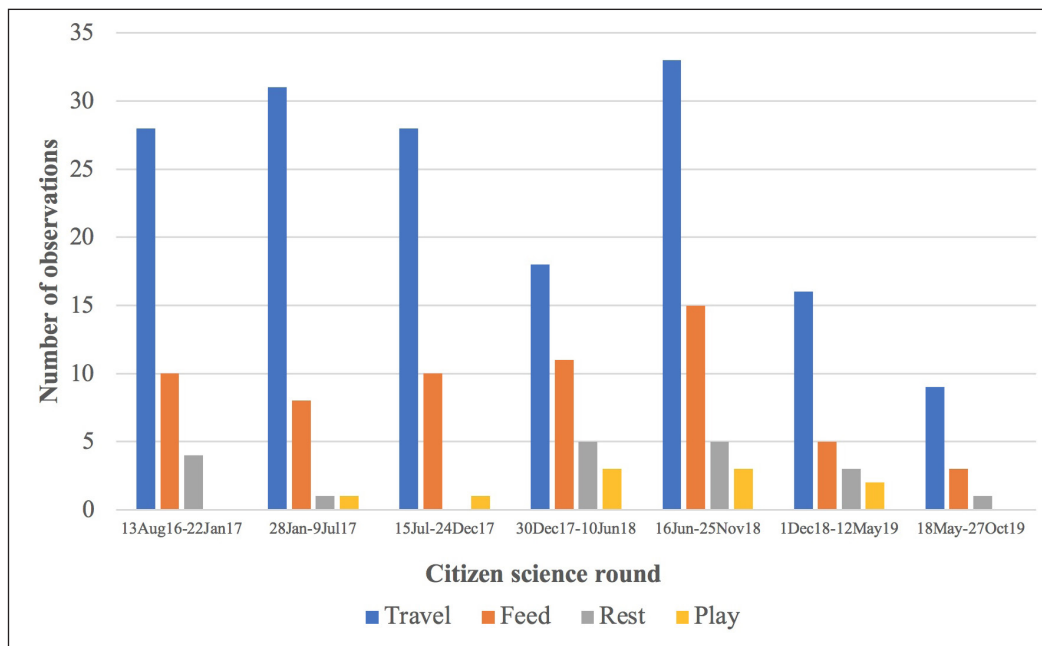


Figure 3. Types of observations (y-axis) recorded in each citizen science round (x-axis).

Table 4. Number of langur sightings and sighting rate.

Citizen science survey period	# of sightings	Rate of sighting (%) [*]	# of volunteers	% of volunteers who saw langurs
1 st (13 August 2016 – 22 January 2017)	22	22.9	31	58.1
2 nd (28 January – 9 July 2017)	26	27.1	31	54.8
3 rd (15 July – 24 December 2017)	29	30.2	35	74.3
4 th (30 December 2017 – 10 June 2018)	17	17.7	40	62.5
5 th (16 June – 25 November 2018)	34	35.4	38	84.2
6 th (1 December 2018 – 12 May 2019)	17	17.7	41	68.3
7 th (18 May – 27 October 2019)	12	12.5	29	58.6
Average	22.4	23.4	35	65.8
Total	157		245	

*Each survey period comprised of 96 survey assignments.

and to the general public through media articles (for example, Tan 2020). Between the beginning of the first training workshop and the end of the seventh citizen science surveys, there were a total of 53 local and international media mentions of Raffles' banded langur (an average of 1.36 mentions per month over 39 months; unpublished report). Notably, there was also an increase in the number of photographs of Raffles' banded langurs being shared on social media (for example, in "Nature Society Singapore" and "Wildlife of Central Catchment Nature Reserve" Facebook pages).

Raffles' banded langurs are rare, elusive, and tree-dwelling, and hence they are difficult to find (Ang *et al.* 2016). With regard to selecting a field survey site, therefore, it was necessary to ensure that the survey route presented a relatively good opportunity for seeing the langurs and that it was accessible to the public so that the volunteers could collect data. The Central Catchment Nature Reserve (CCNR) in the central part of Singapore is the largest nature reserve in the country. It is also home to the entire local population of 67 Raffles' banded langurs (unpublished report). At the eastern periphery of the CCNR are the Lower Peirce Reservoir Park and the Old Upper Thomson Road, both areas accessible to the public and part of the home ranges of the langurs.

Over a period of three and a half years, we recruited 143 people, who were mostly local Singaporeans and were largely tertiary students or working individuals. This demonstrated strong local interest in contributing toward data collection for our native langurs, and that the weekend arrangement in this project was suitable. The citizen scientists completed 631 field survey assignments and recorded a total of 157 sightings of Raffles' banded langurs, which amounted to a 24.9% encounter rate, i.e., one sighting of langurs for every four survey assignments. On average, 65.8% of the volunteers saw the langurs at least once. In addition, high-resolution photographs from citizen scientists helped with the identification of some langur individuals. In a similar approach for the Critically Endangered western African lion (*Panthera leo leo*) in Niokolo-Koba National Park in Senegal, 93 observations of the lions were made by the

guides and their clients over a period of four and a half years, and from photographs contributed by the tourists, the team was able to produce identification sheets for 10 individual lions based on whisker spot patterns (Dagorne *et al.* 2020). For our project, we collated photographs from citizen scientists with sighting locations, group demographics, and data collected by researchers during the weekdays, and were able to confirm five groups of langurs comprising 34 individuals along the survey route.

In planning this citizen science project, we had to bear in mind the feasibility of the task to be implemented by the citizen scientists. A purely scientific survey might be challenging and might not have attracted them. We had to ensure that the amount of data to be collected within a short period of 2.5–3 hours (each survey assignment) was limited to a few meaningful tasks that the general public could complete.

While the training workshops and subsequent surveys by citizen scientists increased public awareness on the presence of the langurs in Singapore, a limitation of our study was that we did not assess the broader impact of citizen science participation on the volunteers with regard to the knowledge gained as well as social and psychological benefits. For future survey sessions, volunteers will be offered a questionnaire before and after the training workshop to determine what they had learned about the langurs and citizen science, benefits that they might have experienced, and also feedback on better ways to improve the citizen science experience.

Citizen scientists were tasked to record sightings using descriptive language in such a way that the scene of the observations could be formed in the reader's mind. We adopted this approach as we were not sure what to expect from citizen scientist observations when we started the program and did not want to lose any information that could be valuable. A disadvantage of this method was that it required careful reading and manual curation of information to translate it into useful data. Future volunteers could be tasked to record specific observations to answer relevant scientific questions for monitoring the langurs. We could provide a

checklist of behavioral activities, for example, for them to check.

Most of the recorded observations were of the langurs traveling, i.e., the citizen scientists were not able to get uninterrupted sightings, which further emphasized the difficulty in using the citizen science program to answer specific scientific questions. A total of 62 feeding observations were recorded across the seven rounds of surveys, but only three species of food plants were identified by the citizen scientists. The three species were commonly seen along the survey route. They can be easily identified and are a regular item in the diet of Raffles' banded langurs (Srivathsan *et al.* 2016). Feeding observations are important as they inform researchers on where feeding activities occur so that more in-depth scientific research can be planned and carried out in those areas. We are planning to set up phenological plots in some of the feeding hotspots to assess the availability of plant parts of the food species identified through our research (Srivathsan *et al.* 2016).

There were also observations of resting and playing, which were good indicators that some level of ease or habituation to a group of observers was achieved. The challenge, however, is to balance the level of habituation of highly threatened animals such as these with any potential risk of poaching. Primates are frequently illegally traded as pets (for example, dusky langurs in Malaysia; Cannon 2019) and hunted for traditional medicine (for example, *Presbytis* langurs in Borneo for their bezoar stones; Nijman 2005; Setiawan *et al.* 2009). While there are no reports of Raffles' banded langurs being hunted or captured in Singapore, over-habituation would make them lose fear of people and lead them to being more vulnerable to other threats such as disease transmission from humans (and vice versa) and human-wildlife conflicts. The selection of a site for a citizen science program must, therefore, be one where there is regular monitoring and enforcement against illegal activities. For the site that we selected, researchers and park staff regularly carry out wildlife surveys during the weekdays, which, like the presence of citizen scientists in the weekends, helps to ensure constant surveillance of the area.

Raffles' banded langurs rarely descend to the ground to travel unless they have to cross between forest fragments that do not have canopy connectivity. Citizen scientists noted three instances of langurs descending from the trees to the road to cross between the forest fragments at a location where trees had been pruned. In the last few years, the National Parks Board (NParks), a member of the Raffles' Banded Langur Working Group, installed rope bridges at crossing points for the langurs, and further installed a Roadway Animal Detection System to slow down traffic along the road (Mohan 2019; Tan 2019). Recently, camera trap footage demonstrated that the langurs had started to use one of the rope bridges (Tan 2020). Such prompt conservation actions could only have been implemented because of timely reports not only from park staff and researchers but also citizen scientists on the ground.

We consider this citizen science monitoring project a success, as it helped raise public awareness about the langurs, with over half of citizen scientists participating seeing this critically endangered primate that is otherwise rarely seen in the wild. Observations collected by the citizen scientists were instrumental in complementing scientific research and catalyzing conservation actions. We hope to make use of the lessons learned from the current project to start a similar citizen science program for Raffles' banded langurs in Malaysia. Most importantly, this project demonstrates a successful conservation partnership between the public, a government agency, non-governmental organizations, and a private institution.

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Author contributions: AA, SJ, VDR, JL wrote the main manuscript text; AA, JL designed the study; AA, SJ, VDR, JL facilitated the study; AA, SJ analyzed the data. All authors reviewed and edited the manuscript and gave final approval for submission.

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Appendix

Table A. Breakdown on recruitment methods of registered attendees to training workshops.

Rounds	Social Media	Word of Mouth	E-mail	Others [e.g., events]	Total registered
2 nd : 28 Jan–9 Jul 17	31	28	16	4	79
3 rd : 15 Jul–24 Dec 17	14	24	22	25	85
4 th : 30 Dec 17–10 Jun 18	8	31	47	6	92
5 th : 16 Jun–25 Nov 18	31	18	24	6	79
6 th : 1 Dec 18–12 May 19	17	16	27	8	68
7 th : 18 May–27 Oct 19	18	25	22	3	68
Total	119	142	158	52	471
Percentage (%)	25.3	30.1	33.5	11.0	100

Note that there was no data from the first training workshop as we did not prepare a questionnaire during online registration.

