The World-Renowned Annual Elephant Gathering in Minneriya, Sri Lanka – Will It Endure?

M. D. Sashini I. Karunatilaka[1], Sumith Pilapitiya[2] and Mayuri R. Wijesinghe[1]*

[1]*Department of Zoology and Environment Sciences, University of Colombo, Colombo, Sri Lanka*
[2]*Yodakandiya, Tissamaharama, Sri Lanka*
Corresponding author's e-mail: mayuri@sci.cmb.ac.lk

Abstract. The reservoir-bed grasslands of the Minneriya reservoir, Sri Lanka, support a large gathering of Asian elephants in the dry season. We conducted observations on elephant numbers over 12 months in 2019/2020 but did not observe as high numbers of elephants as previously. Monthly elephant numbers at the reservoir were linked to the availability of grassland. Changes in water-related parameters of the reservoir owing to the water supply from the Moragahakanda reservoir may account for the observed differences in elephant numbers. Water regulation to mimic the seasonal patterns is necessary for the endurance of the elephant gathering at Minneriya.

Introduction

Minneriya is located in the dry zone of Sri Lanka, which covers two-thirds of the country. The management of water resources in the dry zone for irrigation was the basis of Sri Lanka's ancient hydraulic civilization, which lasted from 200 BC till 1200 AD (Dharmasena 2010). With the collapse of the civilization after 1200 AD the water reservoirs fell into disuse (Fernando 2002). In the 20th century, with the increase in human population, many of the abandoned reservoirs were restored. Re-settlement schemes, restoration of reservoirs, and expansion of agriculture led to a sharp drop in the extents of forest and other wilderness areas in the dry zone, adversely impacting wildlife including elephants.

The availability of fodder is a major factor influencing the presence of elephants (Harris *et al*. 2008). The Asian elephant (*Elephas maximus*) is a mega-herbivore, with a daily food requirement of about 4% of its body weight, whereas lactating females have a higher requirement of about 6% (Sukumar 2003). Hence, elephants are not specialized feeders and consume a wide range of plant species (Vancuylenberg 1977; Sukumar 1990; Samansiri & Weerakoon 2007). However, they demonstrate a preference for grass, which

shows dense growth, and is easy to gather (Sukumar 1990; Fernando 2015; Alahakoon *et al*. 2017). Grass also contains low amounts of secondary compounds and is more digestible than browse (Kos *et al*. 2012). Vancuylenberg (1977) reported that about 50% of the diet of Sri Lankan elephants consists of grass. Reservoir-bed grasslands become available to elephants in the dry season as water is discharged for irrigation and power generation, exposing parts of the reservoir bed where grass sprouts afresh (Ishwaran 2001).

The gathering of elephants at the grasslands of the Minneriya reservoir has been acclaimed as the largest gathering of Asian elephants at a single site (Yapa & Ratnavira 2013). Up to an estimated 400 elephants are thought to gather at the Minneriya and Kaudulla reservoirs (Fernando *et al*. 2011). The Minneriya reservoir receives water from several minor rivers and rain, and it discharges water to downstream reservoirs. Prior to 2018, it also received water from the Mahaweli irrigation scheme, although this decreased during the dry season. With the commissioning of the Moragahakanda reservoir in 2018, the Minneriya reservoir is assured of a year-round supply of water. Release of water from Moragahakanda to Minneriya in the dry season may prevent the exposure of the reservoir bed and the emergence of fresh grass or if

Manuscript Editor: Prithiviraj Fernando

it happens later in the dry season, submerge the grass cover.

We studied how water inflow from Moragahakanda may impact the gathering of elephants in Minneriya, by assessing (i) the number of elephants at the Minneriya reservoir (ii) elephant behaviour with particular reference to feeding on the reservoir bed grassland, (iii) the relationship between monthly elephant numbers and changes in water-related and fodder-related parameters of the reservoir, (iv) the monthly water-related parameters of the Minneriya reservoir in 2019/2020 and 2016/2017, and (v) possible links to the human-elephant conflict (HEC).

Methods

Study site

The Minneriya reservoir is located between latitudes 7°5' – 8°5' North and longitudes 80°5' – 81°0' East, in the Polonnaruwa District in the North Central Province of Sri Lanka (Fig. 1).

The area covered by water at spill level is 2550 ha. The reservoir lies within the Minneriya National Park, which, together with the Minneriya-Giritale Sanctuary, covers an area of 9411 ha (DWC 2008).

Prior to the construction of the Moragahakanda reservoir (commissioned in 2018), the Minneriya reservoir received water via the Elehara-Minneriya-Yodha Ela, from the Bovetenna Scheme, but water was in short supply during the dry season. After 2018, the Minneriya reservoir received water from the Moragahakanda reservoir also via the Elehara-Minneriya-Yodha Ela. The Minneriya reservoir continues to receive water seasonally from several minor rivers – Batu Oya, Erige Oya, Talkote Ara Oya, Kiri Oya and Madyamala Oya.

The reservoir area receives rain mainly from the north-east monsoon from October to January. As elsewhere in the dry zone, there is a prolonged dry season extending from February to September, preceding the main rainy season (October to January) (DWC 2008).
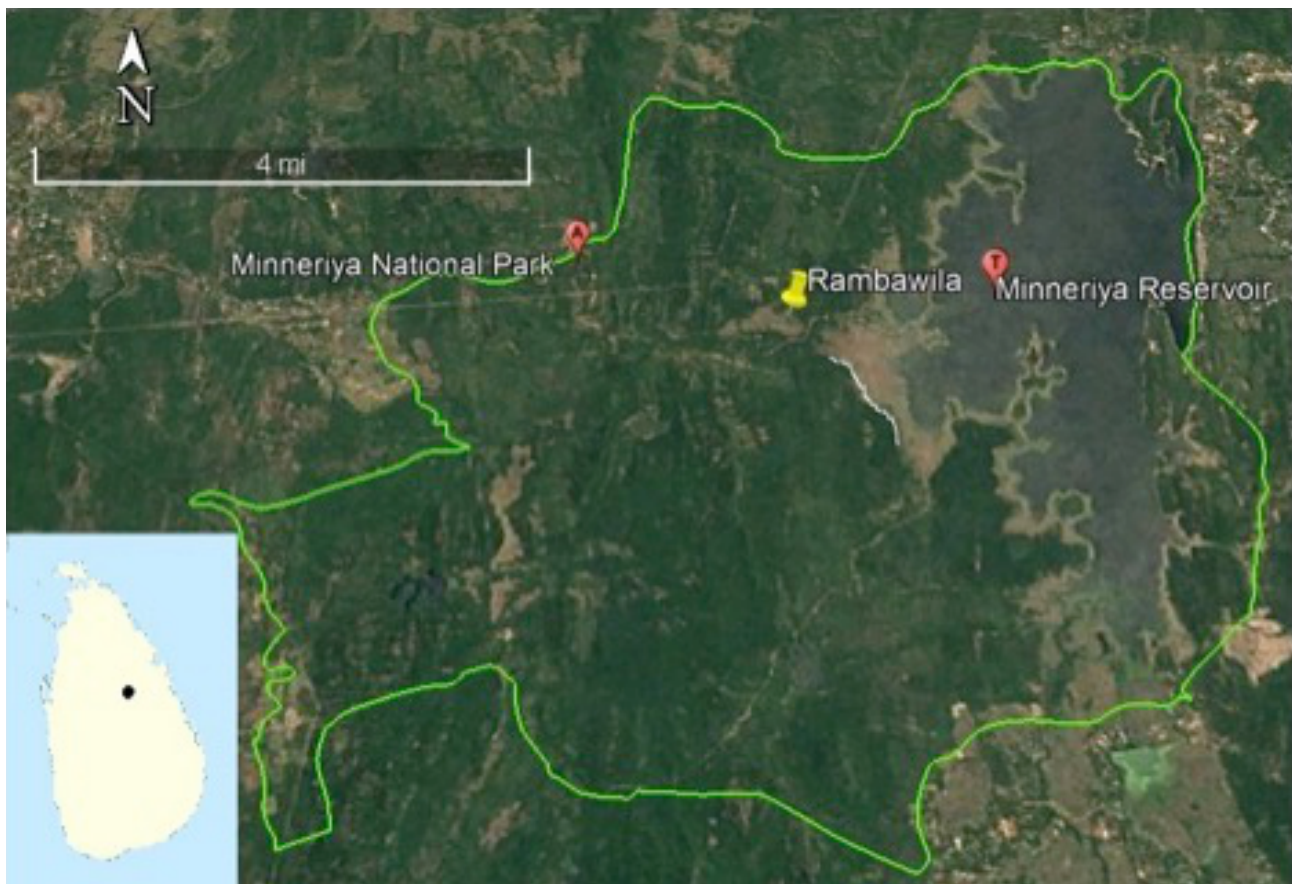

Figure 1. Location of the Minneriya reservoir within the Minneriya National Park and the observation point Rambawila. The tree-line at Rambawila is indicated by the white line.

The Minneriya reservoir releases water to Kaudulla and Kantale reservoirs.

The natural vegetation in Minneriya National Park and the surrounding areas mainly comprises of dry mixed evergreen forest, scrub and riverine forest. Grasslands arise in the exposed reservoir bed during the dry season.

Enumerating elephants

Observations were made on 24 days from February 2019 to January 2020. Counts of elephants were taken on each of two consecutive days within the first ten days of each month. Counts were made from Rambawila, a popular elephant viewing point, which provided wide coverage of the reservoir (Fig. 1). Counts were taken between 14:00 to 17:00 hours. This time frame was selected since elephants usually gather at the reservoir in the afternoon/evening hours. A binocular (Nikon 8×40) was used for observing the elephants.

Recording elephant behaviour

One to three herds within an observable range (estimated at less than 100 m) were selected each month for behavioural observations. A herd was considered to be a group of animals of any age or sex moving together in a coordinated manner (Laws 1970). Herds were selected on arrival, and observations commenced 10 min after all the individuals of that herd were deemed to have arrived. 'Grazing' and 'drinking-and-bathing' were recorded as two separate activities and all other activities were grouped as 'other'. Recordings were made through scan sampling where the activity of each individual in the selected herd was noted at 10-min intervals for up to one hour. For each herd we calculated the percentage frequency of the three activities.

Water-related parameters of the reservoir

We obtained monthly data on mean regulated inflow, mean water volume, mean water depth and rainfall at the Minneriya reservoir, from February to January 2016/2017 and 2019/2020,

from the Irrigation Department. As elephants are known to use seismic and acoustic stimuli for navigation (O'Connell-Rodwell 2007), we assessed data on water inflow on the day preceding the elephant counts, assuming that inflow would create cues that elephants respond to.

Assessing fodder availability

We estimated fodder availability monthly by measuring the distance from the tree line at Rambawila (Fig. 1) to the waterline, and estimating the biomass of grass. The distance to water was used as a proxy for the extent of grassland.

For estimating grass biomass, we harvested the above ground portion of grass in 25 cm × 25 cm plots in the reservoir-bed grassland and in similar plots at the forest edge (up to 30 m into the forest from the tree line), both at Rambawila. A total of five plots, each separated by a distance of 25 m, were sampled per month in the reservoir bed grasslands and in the forest, with a total of 120 plots being sampled during the study (5 plots x 12 months x 2 habitats). For recording dry weight, the collected grass was dried to a constant weight in an oven at 70ºC (Levett et al. 1985).

Human-elephant conflict

HEC incidents (property/crop damage and human injury) from 2015 to 2019 recorded at the Minneriya National Park office were obtained from the Department of Wildlife Conservation.

Statistical analysis

One-way Anova was used to examine for significant differences in the proportions of different behaviour (log transformed) across months. The Pearson's correlation test was used to examine associations between water-related and fodder-related parameters and the mean number of elephants at the reservoir and the chi-square test to examine significant differences in the number of reported crop raids/property damage and human injury in the Minneriya area across years.

Results

Elephant counts and behaviour

The total number of elephants observed on a single day at the Minneriya reservoir during the period February 2019 to January 2020 ranged between zero (in August, December and January) and 160 (day 1 in April) (Fig. 2). There was no seasonal trend in the number of elephants at the reservoir. With the exception of February and June, elephants on the reservoir-bed grasslands were feeding for over 70% of time (Table 1). In February it was possible to observe only a single herd and only one scan sample was recorded for each individual as the herd moved out of the reservoir area within a short time.

Water-related parameters

In 2016/2017 the inflow from June to August was much lower and the water volume and depth from February to June were higher than in 2019/2020 (Fig. 3). In the months following May (i.e. the dry season), the water volume and depth decreased sharply in 2016/2017 but not in 2019/2020. Thus, with respect to water volume and depth, seasonality was seen in 2016/2017 but not in 2019/2020. The rainfall patterns with respect to the monsoon (November to January) and the dry months June to August were broadly similar in 2016/2017 and 2019/2020 (Fig. 3D).
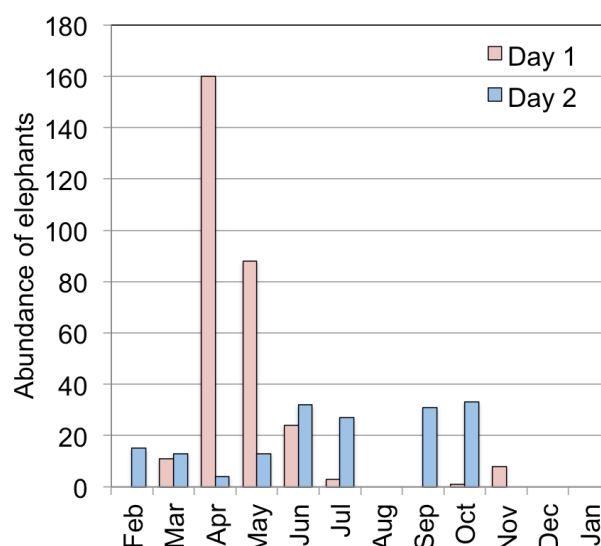

Figure 2. Counts of elephants on two consecutive days each month (solid and empty bars) at the Minneriya reservoir in 2019/2020.

Fodder related parameters

Grass biomass in the exposed reservoir-bed was greater than at the edge of the forest during the months June to December (Fig. 4).

Association between water and fodder related factors and elephant numbers

There was no association between the mean monthly inflow and elephant numbers (mean inflow $r = -0.38$, $P = 0.22$, Fig. 5A). Negative associations were present between the other three

Table 1. Monthly frequencies (mean ± standard deviation) of observed behaviours in herds.

| Month	# Herds	# Individuals	# Scans	Frequency [%]		
				Feeding	Drinking & bathing	Other
February	1	12	12	50.00	0.00	50.00
March	2	20	319	77.02 ± 1.07	0.56 ± 0.79	22.43 ± 1.86
April	2	40	641	83.50 ± 4.17	4.75 ± 5.07	11.75 ± 0.91
May	2	41	450	75.59 ± 1.79	4.68 ± 2.79	19.73 ± 4.58
June	2	55	140	64.72 ± 11.59	5.84 ± 0.58	29.44 ± 12.17
July	3	20	131	70.42 ± 8.55	0.00 ± 0.00	29.58 ± 8.55
August	0	0	0	NA	NA	NA
September	3	82	337	78.59 ± 0.98	8.45±7.38	12.95 ± 7.62
October	2	33	202	72.85 ± 12.69	1.05±1.48	26.11 ± 11.21
November	1	17	119	75.63	0.84	23.53
December	0	0	0	NA	NA	NA
January	0	0	0	NA	NA	NA
F-value				2.80	2.11	2.68
P-value				0.07	0.25	0.08
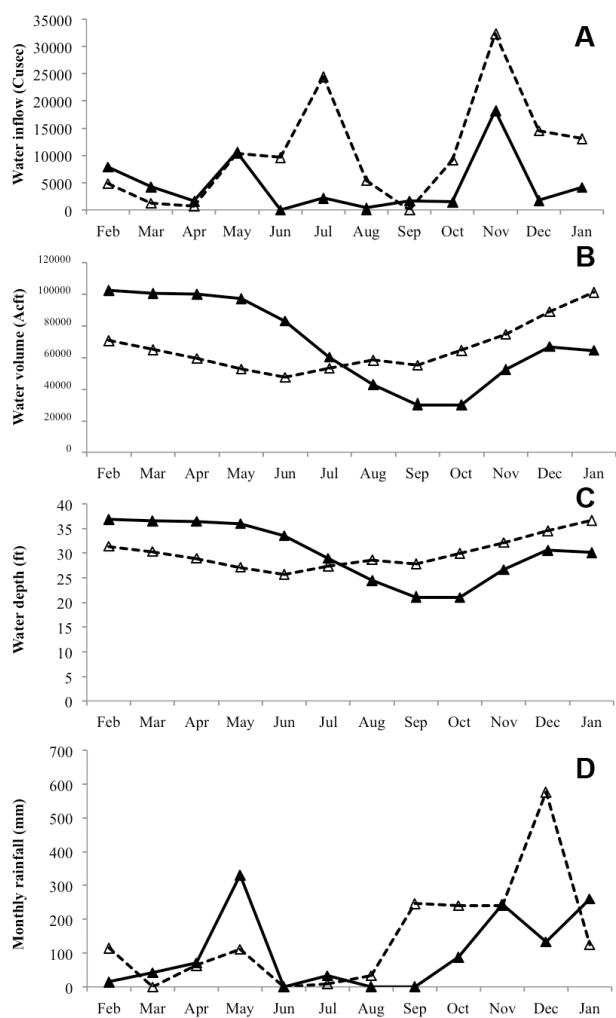
Figure 3. Monthly mean regulated inflow (A), mean water volume (B), mean depth (C) and rainfall (D) for the Minneriya reservoir in 2016/2017 (solid line) and 2019/2020 (dashed line).

water-related parameters and the numbers of elephants (mean water volume r = -0.51, P < 0.09, Fig. 5B; mean water depth r = -0.51, P = 0.09, Fig. 5C; inflow preceding elephant counts r = -0.51, P = 0.08, Fig. 5D).
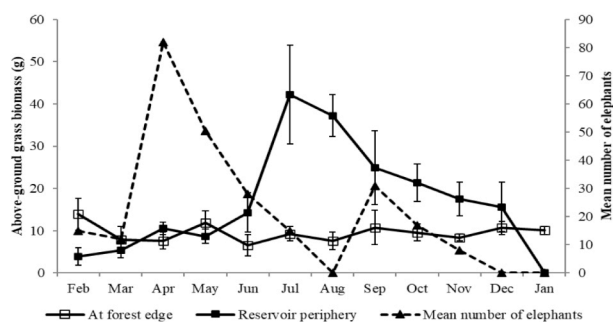

Figure 4. Mean above-ground dry grass biomass at the forest edge and in the reservoir periphery in 2019/2020.

There was a positive association between the numbers of elephants and distance from the forest edge to the water line (r = 0.52, P = 0.08, Fig. 6) but no association with grass biomass at the forest edge or in the reservoir area (forest edge r = -0.08; P = 0.82; reservoir area r = -0.18; P = 0.58) (Fig. 4).
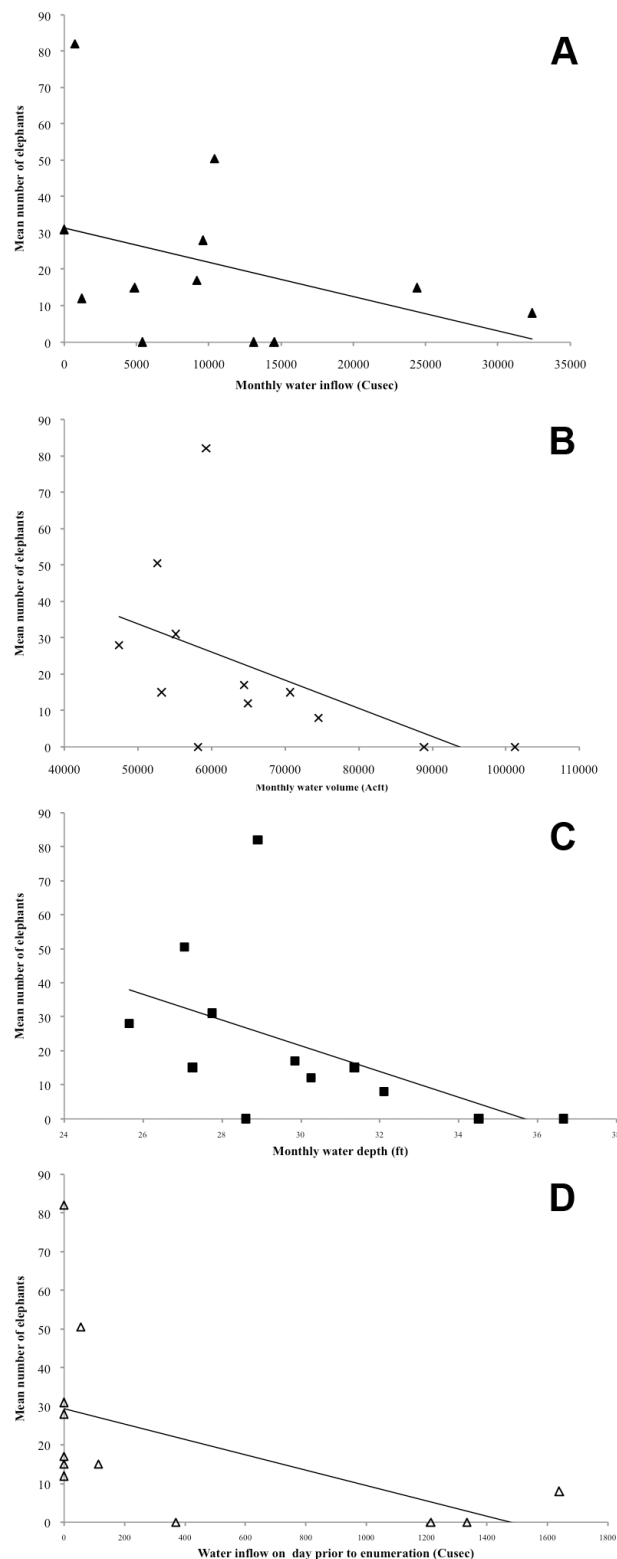

Figure 5. Association between four water-related parameters of the Minneriya reservoir and the mean number of elephants in 2019/2020.
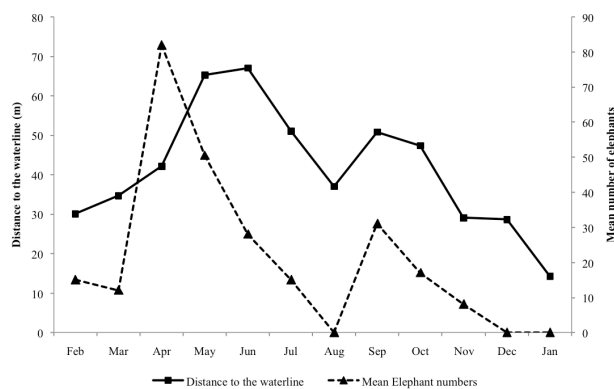
20

Figure 6. Distance from the forest edge to the waterline in 2019/2020.

Trends in the human-elephant conflict

The number of HEC entries around the Minneriya National Park showed a significant difference across years from 2015 to 2019 (X^2 = 52.17, P < 0.001) (Fig. 7). There was around a four-fold increase in the number of reported incidents in 2018 and 2019 compared to the previous years.

Discussion

The largest gathering of elephants enumerated at the Minneriya reservoir by us was 160 and no seasonal trend in numbers was evident. The only other study on elephant numbers in Minneriya found a gradual build-up in the dry season with a maximum of 319 elephants towards the end of the dry season in 2000/2001 (Santiapillai *et al*. 2003). The survey by Santiapillai
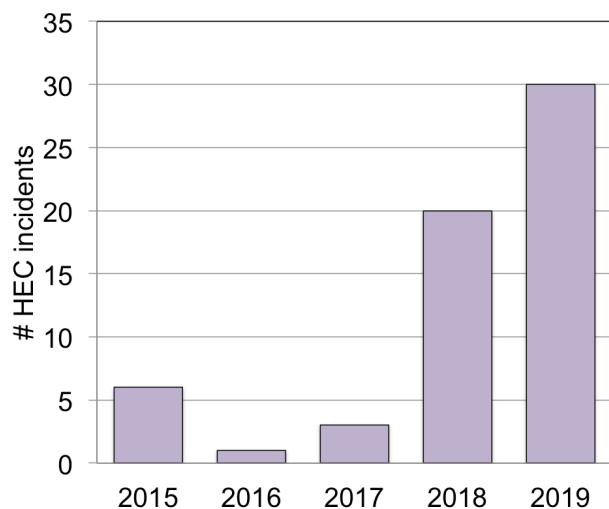

Figure 7. Recorded number of incidents arising from HEC around Minneriya.

et al. (2003) was based on observations conducted while driving 14 km traversing forest and grassland. Although the disparity in the numbers of elephants recorded in the two studies might be attributed to the different methods, comparison with respect to seasonality of the gathering would be valid.

With respect to the impact of water from Moragahakanda, comparison of water-related parameters between 2016/2017 and 2019/2020 showed that water levels were lower during the dry season in 2016/2017. In contrast, there was no seasonal difference in 2019/2020. Differences in rainfall in the two periods may have also contributed to this disparity. There was a negative association between elephant numbers and the mean monthly water volume, depth and inflow on the day prior to enumeration. The link with the inflow maybe due to elephants using seismic and acoustic stimuli to assess the environmental conditions and navigate accordingly (O'Connell-Rodwell 2007). Such a cue might alert the elephants of the possibility of the inundation of the grasslands prompting them to refrain from visiting the reservoir.

We also found that the number of elephants was positively related to the extent of exposed reservoir bed. This is explained by the observation that the elephants gather at the grasslands primarily for feeding. Several studies have shown that grass is a preferred food of Asian elephants (Ishwaran 1981; Katugaha *et al*. 1999; Alahakoon *et al*. 2017). We found that when elephants were on the reservoir bed, over 70% of the time was spent feeding on grass. Although elephants spend only a limited time of the day at the reservoir, this foraging site assumes significance in the dry season when food in other parts of the forest is likely to be scarce. Our study also showed that the grass biomass in the reservoir bed was greater than that at the forest edge, from June to December.

The present study shows that the water levels and pattern of fluctuation in the Minneriya reservoir were different to that before receiving water from Moragahakanda reservoir. Prior to 2018 they were dependent on seasonal inputs, but after 2018 inflow from Moragahakanda dis-

rupted the seasonality. While it is not possible to regulate seasonal inflows, the input from Moragahakanda could be manipulated. Based on the elephant numbers observed by us in comparison to that by Santiapillai *et al*. (2003), we conclude that seasonal fluctuation in water is critical for the endurance of the elephant gathering. Hence, an effort must be made to mimic the pre-2018 seasonal pattern of inundation and exposure of the reservoir-bed. In the wet season when the Minneriya reservoir bed is seldom used by the elephants the reservoir could be maintained at full capacity, and in the dry season the water could be drawn down so exposing the grazing grounds. A common weed *Xanthium indicum* (commonly called agada) invades the exposed beds and is a matter of concern with regard to the Minneriya reservoir (FEOSL 2020). Recharging in the wet season destroys these weeds, allowing for the unhampered resurgence of fresh grass as the water level recedes in the following dry season. Thus, inundation followed by draw down maintains optimal fodder availability for elephants.

Decrease of the grassland in Minneriya reservoir might also have other negative implications. The number of incidents of property and crop damage and injury to humans in the Minneriya area increased sharply in 2018 and 2019 compared with the previous years. While aggravation of the human- elephant conflict in the Minneriya area cannot be entirely attributed to the reduction in grasslands in Minneirya reservoir, it might be one of the contributory factors.

The large gathering of Asian elephants seen at the Minneriya reservoir has been acclaimed as one of the world's wildlife wonders (Lonely Planet 2012). Non-endurance of this elephant gathering would have a profound adverse impact on the tourist industry (Miththapala 2016). Therefore a determined effort needs to be made to maintain an appropriate water regime in the reservoir, while also meeting the demand for irrigation water.

References

Alahakoon AMDB, Pushpakumara EMAB, Ellepola G & Ranawana KB (2017) Food and feeding patterns of Asian elephants in Udawalawe National Park, Sri Lanka. *Gajah* **46:** 4-13.

Dharmasena PB (2010) Evolution of hydraulic societies in the ancient Anuradhapura kingdom of Sri Lanka. In: *Landscapes and Societies*. Martini IP & Chesworth W (eds) Springer, Dordrecht. pp 341-352.

DWC (2008) *Biodiversity Baseline Survey: Minneriya National Park*. Consultancy Services Report. Sri Lanka Protected Areas Management and Wildlife Conservation Project, Department of Wildlife Conservation (DWC), Ministry of Environment and Natural Resources, Colombo.

FEOSL (2020) *Project 'Agada', Removal of IAS (Invasive Alien Species) in Minneriya National Park*. Federation of Environmental Organizations Sri Lanka (FEOSL). <https://feosrilanka.org/projects/project-agada/>

Fernando ADN (2002) *The Ancient Hydraulic Civilization of Sri Lanka*. <http://www.infolanka.com/org/srilanka/hist/70.htm>

Fernando P, Jayewardene J, Prasad T, Hendavitharana W & Pastorini J (2011) Current status of Asian elephants in Sri Lanka. *Gajah* **35:** 93-103.

Fernando P (2015) Managing elephants in Sri Lanka: Where we are and where we need to be. *Ceylon Journal of Science (Biological Sciences)* **44:** 1-11.

Harris GM, Russell GJ, van Aarde RI & Pimm SL (2008) Rules of habitat use by elephants *Loxodonta africana* in Southern Africa: Insights for regional management. *Oryx* **42:** 66-75.

Ishwaran N (1981) Comparative study of Asiatic elephant *Elephas maximus* populations in Gal Oya, Sri Lanka. *Biological Conservation* **21:** 303-313.

Ishwaran N (2001) Integrating elephant conservation with protected area management in Sri Lanka. *Gajah* **20:** 27-38.

Katugaha HIE, de Silva M & Santiapillai C (1999) A long-term study on the dynamics of the elephant (*Elephas maximus*) population in Ruhuna National Park, Sri Lanka. *Biological Conservation* **89:** 51-59.

Kos M, Hoetmer AJ, Pretorius Y, de Boer WF, de Knegt H, Grant CC, Kohi E, Page B, Peel M, Slotow R & van der Waal C (2012) Seasonal diet changes in elephant and impala in Mopane woodland. *European Journal of Wildlife Research* **58:** 279-287.

Laws RM (1970) Elephants as agents of habitat and landscape change in East Africa. *Oikos* **21:** 1-15.

Levett MP, Adams JA, Walker TW & Wilson ERL (1985) Weight and nutrient content of above-ground biomass and litter of a podocarp-hardwood forest in Westland, New Zealand. *New Zealand Journal of Forestry Science* **15:** 23-35.

Lonely Planet (2012) *The Greatest Wildlife Spectacles Around the World.* <http://www.bbc.com/travel/story/20120104-the-greatest-wildlife-spectacles-around-the-world>

Miththapala S (2016) *What is the Value of the Gathering to Sri Lanka Tourism?* <https://www.linkedin.com/pulse/what-value-gathering-sri-lanka-tourism-srilal-miththapala>

O'Connell-Rodwell CE (2007) Keeping an "ear" to the ground: Seismic communication in elephants. *Physiology* **22:** 287-294.

Samansiri KAP & Weerakoon DK (2007) Feeding behaviour of Asian elephants in the north-western region of Sri Lanka. *Gajah* **27:** 27-34.

Santiapillai C, Wijeyamohan S, Wijesundara C & Vandercone R (2003) Population structure, composition and abundance of elephants *Elephas maximus* in Minneriya National Park, Sri Lanka. *Bombay Natural History Society India* **100:** 308-321.

Sukumar R (1990) Ecology of the Asian elephant in southern India. II. Feeding habits and crop raiding patterns. *Journal of Tropical Ecology* **6:** 33-53.

Sukumar R (2003) *The Living Elephants: Evolutionary Ecology, Behaviour, and Conservation*. Oxford University Press, England.

Vancuylenberg BWB (1977) Feeding behaviour of the Asiatic elephant in south-east Sri Lanka in relation to conservation. *Biological Conservation* **12:** 33-54.

Yapa A & Ratnavira G (2013) *The Mammals of Sri Lanka*. Field Ornithology Group of Sri Lanka, Department of Zoology, University of Colombo.