A geographical survey of the wildlife corridor in elephants' seasonal movements between Wasgamuwa National Park and Maduruoya National Park in Sri Lanka

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Abstract

A wildlife corridor is an area of habitat connecting wildlife populations separated by human activities or any other structures. Mega herbivores such as elephants are under great threat due to the habitat loss and disconnection of wildlife corridors. In Sri Lanka as a result of the Mahaweli development project, most of the forested areas have undergone drastic changes mainly due to a huge amount of anthropogenic and developmental activities. In Mahaweli system C, two wildlife corridors connect Wasgamuwa National Park and Maduruoya National Park. Those are the 'Rathkidaoya' wildlife corridor and the 'Hungamalaoya' wildlife corridor. The Hungamalaoya wildlife corridor has been selected for this research. The overall objective of this research is to analyze the role of the Hungamalaoya wildlife corridor in elephants' seasonal movements between Wasgamuwa National Park and Maduruoya National Park. In this research, primary data were collected by using 50 questionnaires among the farmers and 5 key interviews and direct observations of the wildlife corridor. According to the analysis, it has been identified that the annual average elephant movements range from 60 to 80 elephants. Moreover, the movements of elephants based on a day through the Hungamalaoya corridor increase from 4.00 pm onwards. However, from 8.00 pm to10.00 pm, movements are accelerated to a considerable level and the peak is identified between 12.00 - 02.00 am. Besides, Elephants' movements through corridors during January, February, March, November, and December are comparatively less and high between June to September while it peaks in August to around 15. In June, July, and September the number of average elephants' movements are 12. During May and October, it has been identified that average elephants' movements are 4-5. In contrast, it is clear that during the rainy season, elephants' movements are less while their movements are high during the dry season. According to the analysis, the highest number of elephants' movements were recorded during the month of August in the period 2000 - 2010. Meanwhile, from 2011-2020 highest elephants' movement was recorded in September. The average number of elephants that move through the corridor as a herd is 4. Elephants' movements through the Hungamalaoya Wildlife corridor vary according to rainy seasons, harvesting seasons, post-harvesting seasons, and land preparing seasons.

Keywords: National Park, Wildlife Corridor, Disconnection, Mega herbivores

1. Introduction

Wildlife corridors are linear landscape features and their main role is to facilitate the movement of wild animals among the habitats/ecosystems. The term 'Biological Corridors' has been used as ecological corridors, wildlife corridors, animal corridors, habitat corridors, greenways, and green paths (Lindenmayer and Nix, 1993, Meffee and Carroll, 1994). However, potential corridors enable the travel of wildlife from one habitat to another habitat. In General, wildlife corridors are connections across the landscape that link

up areas of biological habitats. They support the natural processes of species function that occur in a healthy environment, including the movement of species to find resources as well as their ecological niches, such as food, water, and safety from other species. These corridors serve as traveling paths for wildlife species between two similar yet isolated habitat patches and provide species with seasonal ecological niches. They enable once-isolated populations of organisms to interbreed, thus increasing genetic diversity as well as species diversity. Generally, wildlife corridors allow animals to access more resources and continue to contribute to their environment and ecosystem processes. In reconnecting isolated habitat patches, these corridors increase the density and diversity of the species. Accordingly, species richness and quality mostly depend on corridors, which provide opportunities for species to link with other habitats (Meffee and Carroll 1994). Therefore, corridors are necessary for the free movement of wild animals without the danger of their habitat conversion into farming fields and other human purposes. However, maintenance of the biological corridors is essential to ensure cross-population genetic flow and allow the movements of wildlife between National Parks, which provides the potential for a large number of species. The main role of biological corridors is to provide free movement of species and to maintain biodiversity, which are vulnerable as a result of species isolation. Therefore, biological / wildlife corridors have been proposed as solutions to habitat and wildlife population fragmentation and species isolation. According to Meffee and Carroll (1994), biological corridors should be included in conservation plans; to increase the connectivity of otherwise isolated patches. There are currently 26 National Parks, together covering an area of 5,734 km^2 in Sri Lanka (Department of Wildlife Conservation, 2013, 2017), and several Protected Areas including National Parks are connected with biological corridors in Sri Lanka. A wildlife corridor is an area of habitat connecting wildlife populations separated by human activities or any other structures. Mega herbivores such as elephants are under great threat due to the habitat loss and disconnection of wildlife corridors. In Sri Lanka as a result of the Mahaweli development project, most of the forested areas have undergone drastic changes mainly due to a huge amount of anthropogenic and developmental activities. Wasgamuwa National Park and Maduruoya National Park are located in the dry zone of Sri Lanka. Maduruoya National Park is located in the Eastern Province as well as the Uva Province. The area of the Maduruoya National Park extends to 588.496 km^2 (Department of Wildlife Conservation, 2013). At the same time, Wasgamuwa National Park is located in the Central Province and North Central Province. The area of the Wasgamuwa National Park extends to 370.629 km^2 (Department of Wildlife Conservation, 2013). Rathkidaoya and Hungamalaoya wildlife corridors connect Wasgamuwa and Maduruoya National Parks. The Southern edges of the National Parks are connected with the Rathkidaoya wildlife corridors and the Northern edge of the Parks, are connected with the Hungamalaoya wildlife corridor. Hungamalaoya wildlife corridor has been selected for this research is lies on the Dimbulagala DS division. Corridors should increase the rate of immigration and thus increase species numbers within a reserve by permitting species that have become extinct to recolonize the reserve (Newmark, 1993). The Hungamalaoya corridor facilitates to maintenance the elephants' seasonal migration between Wasgamuwa and Maduruoya National Parks. Connectivity between the Wasgamuwa National Park and Maduruoya National Park is considered a special conservation for elephants and their migration. Elephant migration through the Hungamalaoya wildlife corridor is very common for a long time but assessing its role in elephants' seasonal migration is rather important.

2. Literature Review

The International Union for Conservation of Nature and Natural Resources defines National Parks under the IUCN Category II: National park: protected area managed mainly for ecosystem protection and recreation as a "natural area of land and/or sea designated to (a) protect the ecological integrity of one or more ecosystems for present and future generations, (b) exclude exploitation or occupation inimical to the purposes of designation of the area and (c) provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible" (Nigel Dudley and Sue Stolton, eds. 2008, p.9). In March 1872 President Grant signed an Act thus giving birth to the world's first National Park. After this, establishing a Natural/National Park as a Protected Area became widespread all over the world. The British also started to establish National Parks in Asian and African colonies during the colonial period. In India, the Jim Corbett National Park was formed in 1936. In Sri Lanka, there have twenty-six National Parks (2021) designated since 1938. Wasgamuwa National Park and Maduruoya National Park are very famous and important National Parks in different perspectives. National Parks will be more effective if they connect with wildlife corridors. According to MacArthur and Wilson's (1967) Theory of Island Biogeography, which states that a species number at a site becomes constant, however composition of a species can be changed by local turn over. Many Protected Areas worldwide are too small to maintain long-term viable populations of many of their resident species. It may be possible in many cases to reduce the adverse "island" effects by linking adjacent Protected Areas with wildlife corridors. Wildlife corridors are defined as habitat that permits the movement of organisms between ecological isolates (Newmark, 1993). According to Mankowski, 2014 a wildlife corridor is exactly may differ depending on its function, the term 'corridor' is commonly defined as a broad, internally varied swath of habitat that allows for or directs the spread of organisms from one region to another. However, biological corridors are valuable conservation tools, which provide connectivity to different landscape (Park et al., 2009).

The Concept of Biological/Ecological/Wildlife Corridors demands preserving the connections between landscapes/protected areas: national parks through corridors. A biological corridor is a geographically defined area that provides connectivity among landscapes, ecosystems, and habitats, natural or man-made, and ensures the conservation of biodiversity and ecological and evolutionary processes. According to Rosenberg et al. (1997), biological corridors may include linear forests, narrow grassland with forest patches and tree remnants, linear mashie areas such as riparian strips, and forest remnants following tree harvesting.

Habitat fragmentation traps species in small isolated patches, which leads to higher extinction rates among largely migrating species (Wilcove et al., 1986; Wilcox and Murphy 1985; Pimmetal. 1988 as cited in Rosenberg et al., 1997). Accordingly, as a result of habitat fragmentation and isolation lead to a decrease in biodiversity. Habitat fragmentation directly influences negatively species dispersal, increases mortality, and leads to dwindling genetic diversity. Accordingly, concern about this loss has driven conservation biologists to discuss the actions that are needed to increase the effective size of local populations and corridors have been advocated as the primary means to connect isolated populations and habitats (Meffe

and Carroll, 1994; Noss 1983; Saunders and Hobbs 1991 as cited in Rosenberg, et al., 1997). Therefore, biological corridors became a solution for connecting and reconnecting wild habitats.

At present, connecting natural landscapes through corridors/greenways is being promoted as sustainable way to conserve biodiversity (Rosenberg, et al., 1997). Species richness and quality mostly depend on biological corridors, which provide opportunities for species to move to other preferable habitats according to the seasons or by other purposes. Principal among these possible strategies has been the recommendation that corridors should be encompassed in conservation plans; to increase the connectivity of otherwise isolated patches (Meffee and Carroll, 1994).

This understanding, together with the public interest in 'greenways', or 'wild lines' has led to the inclusion of corridors/green paths in reserve designs has become a significant conservation approach for protecting and sustaining biodiversity and also Conservation Biologists, Zoogeographers and Land Planners to advocate corridors as most crucial modules in reserve design. According to Dole et al. (2003), even highways that cross natural habitats also included over or underpasses as 'biological corridors' to facilitate species movements and animals prefer to under pass as hidden access. This strategy was motivated by theoretical and empirical observations demonstrating that increased interchange of individuals among populations may increase local and regional population persistence, particularly among small, isolated populations (Meffee and Carroll, 1994).

Biological corridors prevent the processes of fragmentation and isolation of natural habitats, national parks, and biological islands. Further, its acts as a bridge among wild habitats to maintain ecological links and conserve biodiversity including genetic, species and ecosystem diversities. Moreover, ecological corridors facilitate species to migrate and colonize to different habitats according to the seasons and particularly animal species can find new mates in neighboring habitats. Besides, wildlife corridors also help facilitate the re-establishment of populations that have been dwindled as a result of natural disasters. According to Macdonald and Willis (2013), as species move through spatially complex landscapes, they respond to multiple biotic and abiotic factors to maximize access to diverse resources and mates while minimizing risks of mortality. Especially animal species use corridors to roam between parts of a large home range, seasonal migration and for safety purposes. In general, it has been widely accepted that 'In-Situ Conservation' is impossible without 'greenways', or 'wild lines' in conservation and management of biodiversity.

National Parks generally have more species as a result of maintaining the corridors for the purpose of landscape connectivity. Typically, national parks/protected areas need more resources for different types of especially alpha and gamma species (Species alpha: species diversity within a delimited homogeneous area in a one-biotope and Specie gamma: species diversity across a large landscape, connectivity between separate biotopes). This is especially true for large-bodied, long-lived, and highly migrating species (Meffe and Carroll, 1994). In the case of Protected Areas in the Mahweli Wildlife Region, elephants are under stress due to human pressure surrounding the Protected Areas as well as in the elephant corridors. As a study site, Hungamalaoya wildlife corridor, located in the Dimbulagala DS division of Polonnaruwa District is under human pressure. Assessing the role of the Hungamalaoya wildlife corridor in elephants'

movements and preparing a map of the corridor are most important. There were no proper maps of the Hungamalaoya Wildlife corridor. Besides, it is our duty to maintain the corridor for the free movement of elephants between Wasgamuwa National Park and Maduruoya National Park. An effort has been made to analyze the role of the Hungamalaoya wildlife corridor in elephants' seasonal movements between Wasgamuwa National Park and Maduruoya National Park and how biological corridors are effective in maintaining the elephant population as gamma species in the study site.

3. Material and methods

3.1. Study area

The study area of this research is the Hungamalaoya wildlife corridor. The significant part of the corridor is located in the Dimbulagala DS division of Polonnaruwa District. Besides, a small part of the corridor is located in the Dehiattakandiya DS division of Ampara District. However, the entire corridor is located in the dry zone. The average annual temperature of this area is 27.1 °C and the average annual precipitation is 1156mm (Divisional Secretariat Office, Dehiattakandiya, 2019). This area is receiving the highest precipitation from the Northeastern monsoon. The main water source of this area is Hungamalaoya. The following figure: 1, shows the study area of this research.

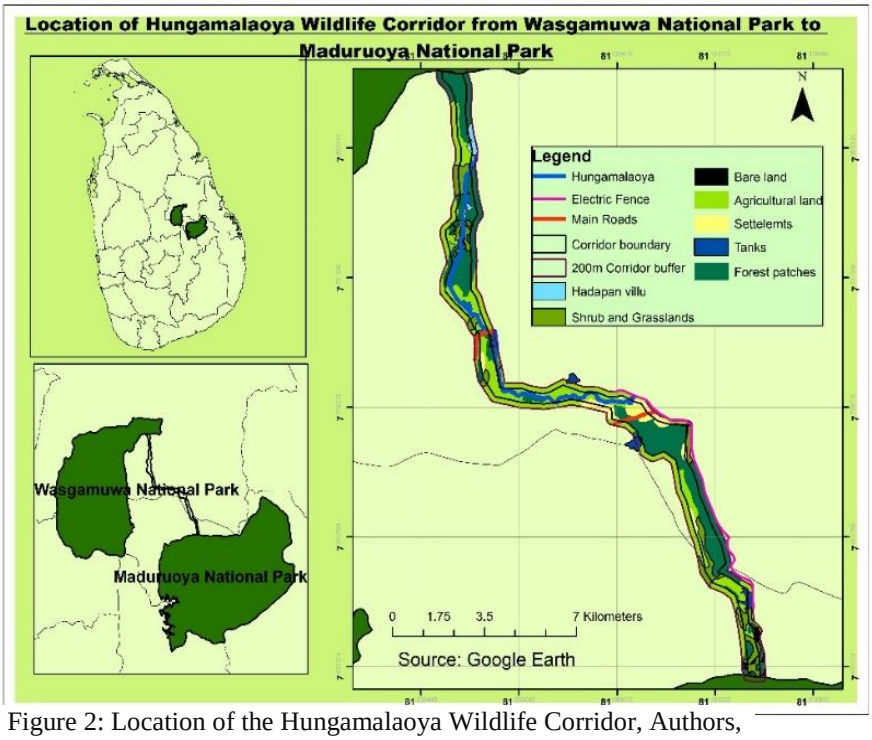

Figure 2: Location of the Hungamalaoya Wildlife Corridor, Authors, 2021, GIS-based on Google Earth

The study area is located in the Mahaweli system "C". As a result of the Mahaweli resettlement project, the government allocated one-acre highland and 2.5 acres of field land per person in between 1982 and 1983. In addition to that, 0.5 acres, of highland was given in 1990. Five main villages have been linked with the corridor. As a result, human activities including farming practices can be observed in the corridor. Moreover, many settlement lands that can be observed along the corridor and inside the corridor. However, forest cover and small forest patches can be observed inside and outsides of the corridor.

3.2. Data collection

Primary and secondary data were collected for this research using various methods. Primary data were collected by conducting 50 questionnaires among the farmers and 5 key informant interviews as well as direct observations of the wildlife corridor. The following figure: 2, shows the data collection methods adopted for this research.

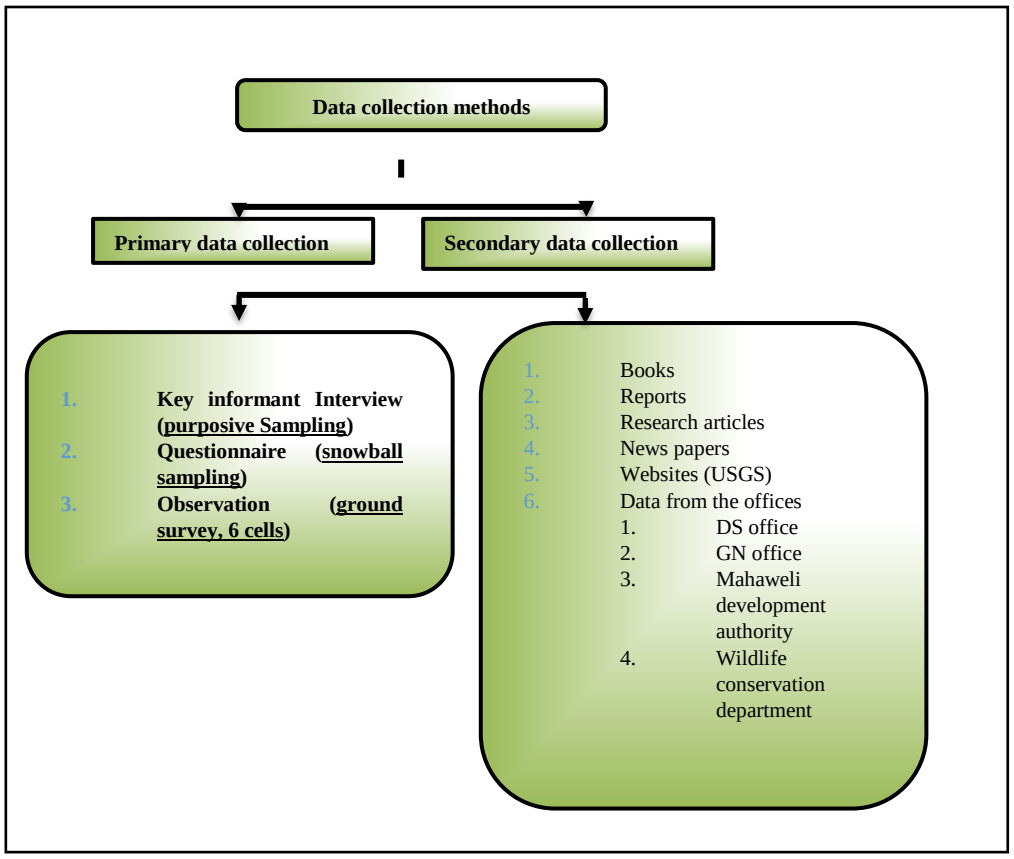

Figure 3: Data collection methods used in this research

Primary data were collected based on field observations, Questionnaire surveys, and key-informant interviews. 'Snowball sampling method' was used to identify the respondents for the questionnaire survey. There are five villages located along the Hungamalaoya wildlife corridor and to represent all five villages ten respondents who have been living there for more than 15 years were selected from each village. The questionnaire survey was carried out from 1st December 2021 to 15th December 2021. As the first step, in first week of December 2021, questionnaires were distributed to the respondents with instructions and it was collected at the end of the second week of December 2021. Unfilled questionnaires (06) and partly filled questionnaires were filled with the support of the respondents and their family members.

In addition to the questionnaire survey, five key-informant interviews were conducted based on the purposive sampling method. Among the selected respondents, 3 key informant interviews were conducted with wildlife officers, one interview was conducted with an environmental officer attached to the Mahaweli Development Authority, and another interview was conducted with Gramaniladari of Kadirapura GN

division. Key-informant interviews were conducted from 14th November to 30th November 2021. Besides the questionnaire survey and key-informant interviews, field observation facilitated as one of the important parts of data collection for this research. Field visits and direct observations were done in five selected locations of the Hungamalaoya wildlife corridor and all these five locations are representing each village situated along the corridor. Field observations were done from mid-November 2021 to end of February 2022.

It was identified through field survey that there were no proper maps of the Hungamalaoya Wildlife corridor in Mahaweli Development Authority or other government departments. The GPS coordinates of the corridor boundary were collected from Mahaweli Development Authority. A GIS-based land use map of the Hungamalaoya corridor was developed for the purpose of this research.

Secondary data were gathered from published materials of Mahaweli Development Authority. Besides, GPS locations of the corridor boundary were also collected from the Mahaweli Development Authority. Moreover, secondary data were collected from the Department of Wildlife Conservation, Dehiattakandiya Divisional Secretary office, and Grama-Niladari office. Further, related secondary data were gathered from books, research articles, newspapers, reports, and websites.

3.3 Data analysis

Collected data were analyzed using Arc GIS, Google Earth, and Microsoft MS Excel. Qualitative information such as opinions, views, narrations, and experiences of respondents in relation to the Hungamalaoya wildlife corridor and seasonal elephants' movements were mainly analyzed using content analysis methods and descriptive analysis Methods. Analyzed qualitative findings were presented according to the main and sub-contents of respondents' direct citations/quotes. Besides, quantitative data were analyzed using Microsoft MS Excel.

4. Result and Discussion

Hungamalaoya wildlife corridor plays a major role in elephants' movement and migration between Maduruoya National Park and Wasgamuwa National Park. A large number of elephants annually move and migrate through this corridor.

4.1. Daily elephant movement through the corridor

According to the analysis, it is recognized that the elephants' movements along the Hungamalaoya wildlife corridor are not the same throughout the day. There is a specific time period in which the elephants move along the corridor and following figure 3 shows the daily movements of elephants through the corridor.

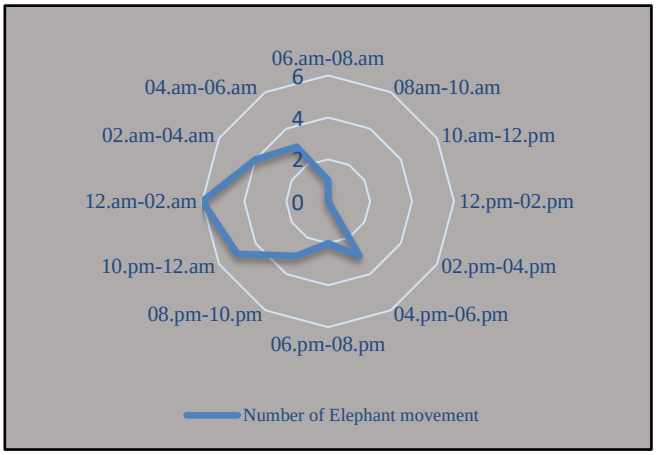

Figure 3: Daily movements of elephants through the corridor in a day, Authors, 2021

Based on the analysis, the figure clearly shows that the elephants' movements through the corridor are rather less from 8.00 am to 4.00 pm. As a common pattern among all wildlife regions of the country, the movements of elephants through Hungamalaoya corridor begin to increase from 4.00 pm onwards. However, from 8.00 pm to10.00, pm movements heighten to a considerable level and the peak is identified between 12.00 - 02.00 am. Again, the movements of elephants dramatically ~~in~~ decrease from 04.00 am to 06.00 am. Accordingly, elephants' movements are high during the dark hours and less during the daytime. This trend is proven according to the following key-informants' view:

> *"Elephants are emerging from the jungle in the evening and then can be seen as herds in the small forest paths and lakes of nearby areas until nightfall. Later at night, most of the elephants migrate through the corridor, and in the morning movements decrease again."*
>
> K.M.Amila Kumara , 38 years, Wildlife Officer, Mahawanawela - WCD

4.2. Annual average movement of elephants through the corridor.

Hungamalaoya wildlife corridor plays a major role in elephants' migration and movement between Wasgamuwa National Park and Maduruoya National Park and it provides resources, such as food and water for elephants while travelling through corridor. There are many forest patches along the corridor and it provides shade for elephants. These favorable conditions intensify the elephant movement through the corridor. Based on the analysis, the annual average movements of elephants through the corridor range between 60 and 80 and the annual average movement of elephants is 70 elephants. The annual average movement has been further elaborated according to the monthly movements of the elephants through the Hungamalaoya wildlife corridor. The following figure: 4 shows the Monthly movement of elephants through the corridor.

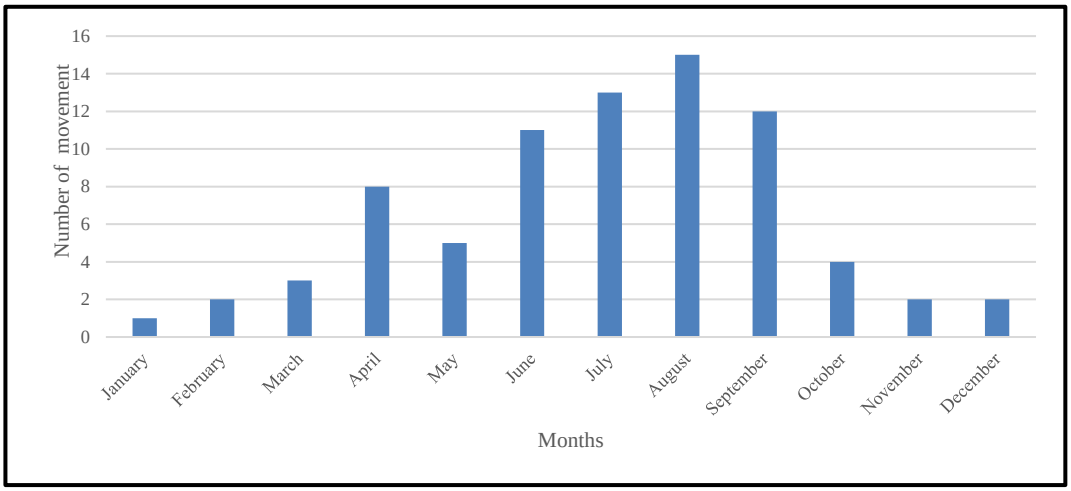

Figure 4: Monthly movement of elephants through the corridor, Authors, 2021

According to figure 4, elephants' movements through corridors during January, February, March, November, and December are comparatively less and in January it is just 1-2 on average. However, elephants' movements are high between June to September and peak in August, which is around 15. In June, July, and September the number of average elephants' movements is 12. During May and October, the average elephant's movements are 4-5. Moreover, elephants' movements through the Hungamalaoya Wildlife corridor vary from harvesting seasons, post-harvesting seasons, and land preparation seasons.

4.3. Relationship between precipitation and elephants' movements through the corridor

According to the analysis, it has been identified that there is a direct relationship between precipitation patterns in the study area and elephants' movements through the corridor. Figure 5: shows the relationship between precipitation and elephants' movements.

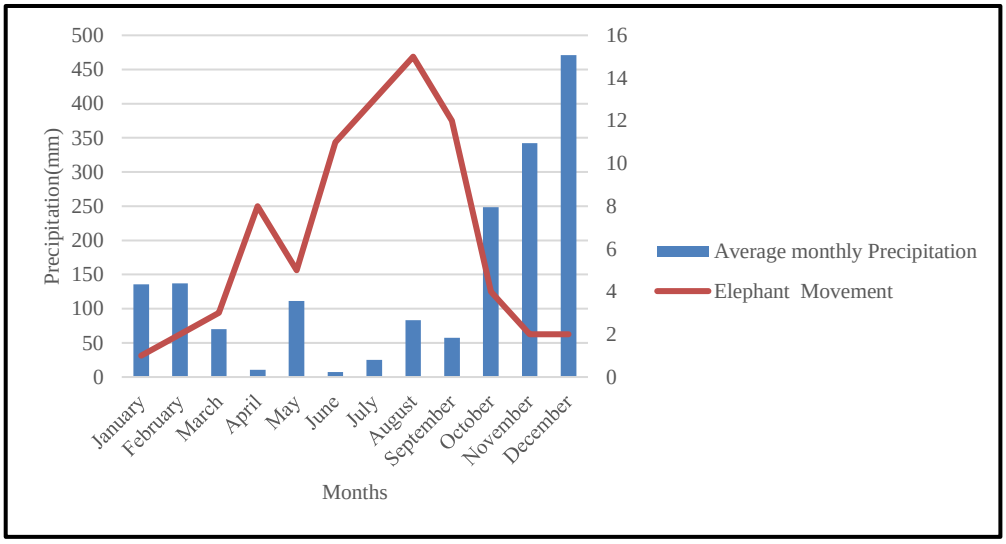

Figure 5: Relationship between precipitation and elephants' movements, Authors, 2021

According to Figure 5 study area is receiving high precipitation in months of October, November, December and January (Northeast monsoon period and 2nd inter-monsoon period). It has been recognized that elephants' movements are comparatively less during rainy seasons, especially at the beginning of the 2nd inter-monsoon and during the Northeast monsoon period. The study area is receiving the highest precipitation in December and the lowest elephant Movements have been identified in January. However, during the first inter-monsoon period, the amount of precipitation is decreasing and the elephants' movements through the corridor are dramatically increasing as a trend. In the Southwestern monsoon period (May to September), the study area is receiving very less precipitation; therefore, elephants' movements are relatively high at that time. In contrast, it is clear that during the rainy season (High precipitation), elephants' movements are less and in dry seasons, the movements of elephants through the corridor are high. In the dry season (less precipitation), elephant movements are increasing. The main reason for this relationship is that during the rainy season, forest area is plentiful with water resources and favorable foods, therefore elephants live inside the forest areas and their movements are less. Further, the following respondents' narration also revealed the relationship between precipitation patterns and elephants' movements in the study area.

> *"Due to the lack of adequate food and water in the forests during the dry season, elephants begin to migrate to find enough food and water in other forest areas and nearby places using the wildlife corridor. So, in dry season elephants' movements are high through the Hungamalaoya wildlife corridor. Also, during the rainy season, elephants are less likely to migrate through this corridor as they have enough food and water in their habitat"*
>
> R. R. Shantha, 48 years, Wildlife officer, Weheralagala Wildlife conservation office.

4.4. Number of elephants in a herd moving through the Wildlife corridor

Usually, there are single elephants and small elephant herds moving through the Hungamalaoya wildlife corridor. According to the analysis, the following table 1 shows the number of elephants in a herd moving through the corridor.

Table 1. Number of elephants in a herd moving through the Wildlife corridor

Number of elephants in a herd	No of respondents
1	8
1-2	15
2-5	23
More than 5	4

According to the table, the highest number of respondents (23) recorded that there are 2-5 elephants in a herd migrating through the corridor. Secondly, 15 respondents recorded that there are 2 elephants in a herd. 4 respondents stated, there are more than 5 elephants in one herd migrating through the corridor.

5. Conclusion

In this research, the role of the wildlife corridor in elephants' seasonal (day based, annually, and from 2000 to 2022) movements between Wasgamuwa National Park and Maduruoya National Park was examined. According to the analysis, the annual average elephant's movements is 70. Moreover, the movements of

elephants based on a day through the Hungamalaoya corridor are high between 12.00 - 02.00 am. Besides, Elephants' movements through corridors from January to March, November, and December are less while their movements are high between June to September. It was identified that during the rainy season, elephants' movements are less and during the dry seasons, movements of elephants through the corridor are high. Between 2000 and 2020, the highest number of elephants' movements was recorded during August and September. The number of elephants in a herd is 4 on average when it is moving through the corridor. Elephants' movements through the corridor vary according to rainy seasons, harvesting seasons, post-harvesting seasons, and land preparation seasons. It is crucial to maintain the Hungamalaoya wildlife corridor free of elephant movements and it needs more attention from related authorities.

5. Acknowledgement

Our sincere thanks to respondents nearby the Hungamalaoya wildlife corridor, Officers attached to the Wildlife conservation department, and the Mahaweli development authority.

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