ISSN 1391-0256

Journal of the Sri Lanka Association for the Advancement of Science

Volume 5 Issue 1 2023

JSLAAS

Founded in 1944 and incorporated by the Act of Parliament No 11 of 1966.

Journal of the Sri Lanka Association for the Advancement of Scienceis a biannual publication. Selected research work from annual research sessions (based on scientific merit) as well as other research articles are invited to submit research manuscripts as per the guidelines provided by SLAAS. SLAAS members may also separately submit their papers for publication.

The Journal can be accessed on-line to view and download the full text of the articles published respective to the volumes free of charge

Submission Manuscript

Only online submission, Web: https://journal.slaas.lk, ***e-ISSN: 2682-6992***

Members of the Editorial Board

Exchanges: Please address all requests to the Secretary, *Sri Lanka Association for the Advancement of Science, "VidyaMandiraya" 120/10, Wijerama Mawatha Colombo 07, Sri Lanka*

Table of Contents

INTRODUCTION

Sesamum indicum L. (*S. indicum*) is usually known as sesame in English, "*Tila*" in Sanskrit, and "*Thala*" in Sinhala. It is one of the world's oldest oilseed crops. It is used for nutritional, medical, and industrial applications worldwide. *S. indicum* is a wildly used medicine in Ayurveda and traditional medicine in Sri Lanka. Stem, Leaves, Seeds, and Oil have medicinal values.

This study aims to analyze the most recent research findings about the pharmacological effects of *S. indicum*.

METHODOLOGY

A systematic review of published full research papers reporting the pharmacological effects of *Sesamum indicum* was designed based on the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyzes) statement guidelines (Tricco *et al.*, 2018). Eligibility criteria are based on the PICO (Population, Intervention, Comparison, Outcomes) approach, study design, Language, and date.

Types of Studies

In vitro, in vivo, and clinically proven pharmacological effects were explored in this systematic study.

Inclusion Criteria

All the published full research papers from 2011 to May 2022, written in English, studied the pharmacological effects of *S. Indicum* were included.

Exclusion Criteria

Other than English, research articles were written in various other languages; Research papers published before 2011, abstract-only papers, journals with no full text available, case reports, case series, systematic review studies, and literature reviews were all eliminated.

Types of Outcomes

The primary outcome was the pharmacological effect, and the secondary outcome was the safety or adverse effects of *S. indicum*

Search Strategy

A comprehensive search of previously published research articles was conducted in PubMed, Scopus, and Cochrane library databases for studies published between January 2011 and May 2022. The keywords used to search for articles included "*Sesamum indicum*." Other filters were selected as the limit to medicine, open access, Full-text articles, journal articles, and written English.

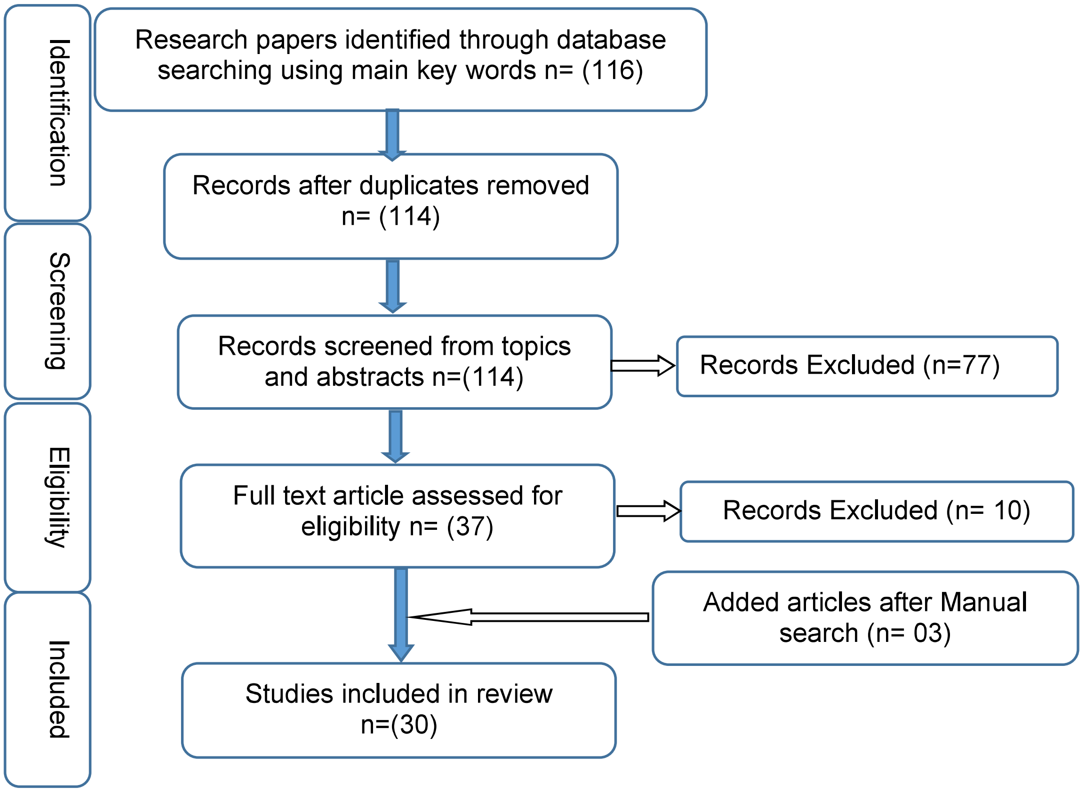

Figure 1: Search strategy

Evaluation of Article Quality

Two authors independently assessed the quality and acceptance of the articles and discrepancies were discussed until an agreement was reached.

Data Extraction

Information related to the study was collected, including the pharmacological activity, type of extract/used part, test method, laboratory organism/animal used, and Reference.

RESULTS AND DISCUSSION

Using the above-mentioned search parameters, the following number of research articles were found in the various databases; PubMed (n=03), and Cochrane library (n=39) and Scopus (n=75). After removing duplicates there were 114articles and those articles were further screened firstly by reading topics and abstracts and secondly reading full text and which did not match with the inclusions were removed. After removing those articles there were 27 articles and after adding 03 additional articles finally 30 articles were included in systematic review. Figure 1 summarizes the search approach. Finally, 08 clinical trials (Table 01), 11 in vivo studies (Table 02), and 15 in vitro research (Table 03) were analyzed (Some researchers conducted more than one study).

Table 1: Clinical Studies

	Pharmacological Activity	Used Part	Test Method	Reference
01	Analgesic effect	sesame oil	Randomized clinical trial	(Shamloo *et al.,* 2015)
02	Reduce muscle damage and oxidative stress	White Sesame seeds paste	Experimental, randomized, and placebo controlled. study	(Barbosa *et al*., 2017)
03	Inducing menstrual bleeding and maintaining regular menstruation	Powdered sesame	A single-blind randomized controlled clinical trial	(Yavari *et al.,* 2016)
04	Removal of retained. products of conception and the reduction of the severity of pain and vaginal bleeding	Sesame grinding powder	An open label randomized controlled clinical trial	(Aghababaei *etal*., 2021)
05	Analgesic effect	Sesame oil	A randomized controlled trial	(Shamloo *et al.,* 2019)
06	Effects on knee osteoarthritis	Sesame seeds powder	A randomized clinical trial	(Sadat *et al.,* 2013)
07	Effect on Lipid disorders	Paste of sesame seeds	A randomized clinical trial	(Mirmiran *et al.,* 2013)
08	Induce menstrual bleeding	Powdered sesame	Pilot study	(Yavari *et al.,* 2014)

Table 2. In-vivo Basic Experimental Studies

	Pharmacological Activity	**Type of extract/ Used part**	**Laboratory Organism/ Animal Used**	**Reference**
01	Anti-rheumatoid activity	Ethanolic extract of seeds	Wistar albino rats	(Ruckmani *et al.*, 2018)
02	Anti-Atherosclerotic action	Sesame oil	female LDLR - / - mice	(Narasimhulu *et al.,* 2015)
03	Anti-Inflammatory action	Sesame oil	female LDLR - / - mice	(Narasimhulu *et al.,* 2015)
04	Anti-Inflammatory and Antioxidant Activities	Sesame oil aqueous extract	Swiss Webster mice	(Selvarajan *et al.,* 2015)
05	Diminishes bone mass and bone formation	Methanol extracts of sesame seeds	Ovariectomized Female Wistar rats	(Tachibana *etal.,* 2020)
06	Diabetes-induced cardiac dysfunction	Sesamin dissolved in olive oil	STZ-induced type I diabetes rat model	(Thuy *et al.,* 2016)
07	Anti-cancer effect	Sesamol (one of the lignans in sesame seeds	6 weeks old male min mice, Apc mutant mice	(Shimizu *et al.,* 2015)
08	Reduced dementia	Sesamin and sesamolin (lignans in *S.indicum*)	Five-week-old male Slc:ddy mice	(Matsumura *et al.,* 2016)
09	Protects the femoral head from Osteonecrosis	Sesamin, isolated from *S.*	male Sprague-Dawley	(Deng *et al.,*2018)

		*indicum*seeds	rats	
10	Increased vitamin K concentrations	Sesamin extracted from white sesame seeds	male Wistar rats	(Hanzawa *etal.,* 2013)
11	Induced growth and development of mammary gland tissue	Pellets with sesame seeds	female Albino rats	(Al-Bazii *et al.,* 2019)

Table 3. In-Vitro Studies

	Pharmacological Activity	Type of extract	Test method/ Laboratory Organism	Reference
01	Anti-helicobacter pylori Activity	Ethanol extract of Leafe	*Helicobactor pylori*	(Masadeh *et al.,* 2014)
02	Anti-bacterial effect	Hexane, Ethyl acetate, and Ethanol extracts of seeds	*Staphylococcus aureus, Enterococcus faecalis, Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumoniae, and Acinetobacter baumannii*	(Hossan *et al.,*2018)
03	Anti-Cancer effect	Dichloromethane extract of leaves	Human myeloid leukemia, human hepatocellular carcinoma, human lung carcinoma, human breast adenocarcinoma, and human Colon cancer cell lines	(Iweala *et al.,* 2015)
04	Free radical scavenging activity	Ethanolic extract of *S. indicum*leaves	DPPH free radical scavenging activity	(Iweala *et al.,* 2015)
05	Anti-Inflammatory and	Sesame oil aqueous	RAW 264.7 cell s and	(Selvarajan *et al.,*

	Antioxidant Activities	extract	human umbilical vein endothelial cells (HUVECS)	2015)
06	Pancreatic lipase inhibition and reducing total body fat	*S. indicum* extract (70%)	Pancreatic lipase (Pancreatic lipase assay)	(Badmaev *et al.,* 2015)
07	Anti-cancer activity (Colon cancer)	Sesamol (one of the lignans in sesame seeds	Human colon cancer cells	(Shimizu *et al.,* 2015)
08	Impacts on T and B lymphocyte activities	sesame seeds oil and sesamol	spleen cells of 8-10 weeks old female or male Balb/c mice	(Khorrami,Daneshmandi & Mosayebi, 2018)
09	Antioxidant and hypoglycemic activities	Ethanolic and aqueous extracts of *S. indicum* seeds	DPPH radical scavenging assay and Glycogen phosphorylase enzyme assays	(Hilmi *et al.,* 2014)
10	Antioxidant and antiproliferative activities	Six sesame seed varieties (Three black and three white)	Oxygen Radical Absorbance Capacity (ORAC) and antiproliferative activity (EC50) against HepG2 Cells	(Zhou *et al*., 2016)
11	Antioxidant and Anti-Colon Cancer Activities	Ethanol extract of *S. indicum*leaf	DPPH assay, FRAP and cell viability assay. Human colon cancer cell lines	(Kim *et al.,* 2021)
12	Pro osteoblastic and anti-osteoclastic	Methanolic extract of *S. indicum*	Osteoblastic MC3T3-E1 cells (mouse calvarial	(Suzuki *et al.,*2018)

	activity		origin)	
13	Alleviate neurodegeneration	Sesamin, isolated from *S. indicum* seeds	Rat pheochromocytoma (PC12) cells	(Udomruk *et al.,* 2020)
14	Anti-melanogenesis activity	Sesamol, an active lignan isolated from *S. indicum*	The melan-a melanocyte line	(Baek and Lee, 2015)
15	Anti-allergic activities	Fermented Sesame	The human keratinocyte HaCaT cell line	(Jung et al., 2018)

Since ancient times, the S. indicum has been crucial in helping treat many disease problems in humans. According to the research studies, its anti-cancer, antioxidant, antibacterial, anti-atherosclerosis, anti-inflammatory, analgesic, anti-allergic, menstrual bleeding inducing, skin whitening, neuroprotective, etc. activities were all scientifically demonstrated. Bioactive compounds, especially lignans (Samin, Sesamin, Sesamolin, Sesamol, Saminol, Sesaminol, Sesamolactol, Sesamolinol, etc.) are responsible for pharmacological activities. Three types, black, white, and red, are used in conventional medicine and Ayurvedic medicine to treat various medical conditions, including gynecological disorders, rectal disorders, and urinary tract disorders. Further, several plant organs, especially seeds, seed oil, flowers, stem, and the entire plant, are utilized to make various medicinal preparations, including decoctions, powders, oils, alkalizes/Kshara, etc. (Anonymous, 1994). According to this study different plant organs, Seeds, leaves, seed extracts and oil were tested. Most clinical trials frequently used seed paste or powder, and roots had yet to be evaluated. Six types of sesame seeds were evaluated by Zhou et al., who concluded that the black variety outperformed the other five varieties as an antioxidant supplement. Likewise, Ayurveda claims that black seeds have more therapeutic benefits (Anonymous, 1994).

CONCLUSION

Sesamum indicum's pharmacological properties are primarily highlighted in this review and many pharmacological effects of Sesamum indicum were scientifically proven by in vitro and in vivo studies. More clinical research must be done to fully understand its therapeutic potential and need to conduct scientific safety assessments further. Especially many gynecological disorders, Urinary and rectal diseases are treated with S. indicum, particularly in traditional and Ayurvedic medicine; nevertheless, there are very few clinical studies on such illnesses or ailments. Sesamum indicum was also used to treat diseases in Ayurveda and traditional medicine as a raw drug and in various pharmacological preparations. Thus, studies using those pharmacological formulations are also needed to prove their therapeutic value. Hence, limitations were identified in those studies, such as limited clinical research, not claiming all pharmacological actions, and not testing some medicinally used parts.

REFERENCES

1. Aghababaei, Z., Nejatbakhsh, F., Mazaheri, M., Shirazi, M., Feizi, A., Bozorgi, M., Bioos, S. (2021). Efficacy of Sesame (Sesamum indicum L.) in the Management of Incomplete Abortion: An Open-Label Randomized Controlled Clinical Trial, Complement Med Res. Retrieved fromhttps://doi:10.1159/000510901
2. Al-Bazii, S.J., Al-Masoudi, L.J., Obeid, A.K. (2019). Histological Effects of Sesamum Indicum Seeds on Mammary Gland tissue in Female white Rats, 2019 IOP Conf. Ser.: Mater. Sci. Eng. 571, 012057. Retrieved fromhttp://doi:10.1088/1757-899X/571/1/012057
3. Anonymous. (1994). Ayurveda Pharmacopoeia Part two, Department of Ayurveda, Sri Lanka, Government press.
4. Badmaev, V., Hatakeyama, Y., Yamazaki, N., Noro, A., Mohamed, F., Ho, C., Pan, M. (2015). Reprint of “Preclinical and clinical effects of Coleus forskohlii, Salacia reticulata and Sesamum indicum modifying pancreatic lipase inhibition in vitro and reducing total body fat”, Journal of functional foods, 18, 994-1001.
5. Baek, S.H., Lee, S.H. (2015). Sesamol decreases melanin biosynthesis in melanocyte cells and zebrafish: Possible involvement of MITF via the intracellular cAMP and p38/JNK signalling pathways, Experimental Dermatology, 24,761–766.
6. Barbosa, C.V.D.S., Silva, A.S., Oliveira, C.V.C.D., Massa, N.M.L., Sousa, Y.R.F.D., Costa, W.K.A.D., Silva, A.C., Delatorre, P., Carvalho, R., Braga, V.D.A. and Magnani, M. (2017). Effects of Sesame (Sesamum indicum L.) Supplementation on Creatine Kinase, Lactate Dehydrogenase, Oxidative Stress Markers, and Aerobic Capacity in Semi-Professional Soccer Players, Front. Physiol. 8:196.Retrieved from http://doi:10.3389/fphys.2017.00196
7. Deng, S., Jian-Lin Zhou, J.L., Fang, H.S., Nie, Z.G., Chen, S. and Peng, H. (2018). Sesamin Protects the Femoral Head from Osteonecrosis by Inhibiting ROS-Induced Osteoblast Apoptosis in Rat Model, Physiol. 9:1787.Retrieved from https://doi:10.3389/fphys.2018.01787
8. Hanzawa, F., Nomura, S., Sakuma, E., Uchida, T., and Ikeda, S. (2013). Dietary Sesame Seed and Its Lignan, Sesamin, Increase Tocopherol and Phylloquinone Concentrations in Male Rats, The Journal of Nutrition.Retrieved fromhttps://doi:10.3945/jn.113.176636
9. Hilmi, Y., Abushama, M.F., Abdalgadir, H., Khalid, A. and Khalid, H. (2014). A study of antioxidant activity, enzymatic inhibition and in vitro toxicity of selected traditional sudanese plants with anti-diabetic potential, BMC Complementary and Alternative Medicine, 14:149.
10. Hossan, M.S., Jindal, H., Maisha, S., Raju, C.S., Sekaran, S.D., Nissapatorn, V., Kaharudin, F., Yi, L.S., Khoo, T.J., Rahmatullah, M. & Wiart, C. (2018). Antibacterial effects of 18 medicinal plants used by the Khyang
11. tribe in Bangladesh, Pharmaceutical Biology, 56:1,201-208. Retrieved from http://doi:10.1080/13880209.2018.1446030
12. Iweala, E.E.J., Liu, F.F., Cheng, R.R., Yan Li, Omonhinmin, C.A., Zhang, Y.J. (2015). Anti-Cancer and Free Radical Scavenging Activity of Some Nigerian Food Plants in vitro, International Journal of Cancer Research, 11(1), 41-51.

13. Jung, T.D., Choi, S.I., Choi, S.H., Cho, B.Y., Sim, W.S., Xionggao, H., Lee, S.J., Park, S.J., Kim, D.B., Kim, Y.C., Jin-Ha Lee, J.H., Lee, O.H. (2018). Changes in the Anti-Allergic Activities of Sesame by Bioconversion, Nutrients10, 210. Retrieved from http://doi:10.3390/nu10020210
14. Khorrami, S., Daneshmandi, S., Mosayebi, G. (2018). Sesame seeds essential oil and Sesamol modulate the pro-inflammatory function of macrophages and dendritic cells and promote Th2 response, Med J Islam Repub Iran., 32:98. Retrieved from https://doi.org/10.14196/mjiri.32.98
15. Kim, S.,Yang, H.Y., Lee, H.J. and Ju, J. (2021). In Vitro Antioxidant and Anti-Colon Cancer Activities of Sesamum indicum L. Leaf Extract and Its Major Component, Pedaliin, Foods, 10, 1216. Retrieved from https://doi.org/10.3390/foods10061216
16. Masadeh, M.M., Alkofahi, A.S., Alzoubi, K.H., Tumah, H,N. & Bani-Hani, K. (2014). Anti-Helicobactor pylori activity of some Jordanian medicinal plants, Pharmaceutical Biology, 52:5, pp.566-569.Retrieved from http://doi:10.3109/13880209.2013.853811
17. Matsumura, S., Murata, K., Zaima, N., Yoshioka, Y., Morimoto, M., Matsuda, H., Iwaki, M. (2016). Inhibitory Activities of Sesame Seed Extract and its Constituents against β-Secretase, Natural Product Communications,11 (11),1671 – 1674.
18. Mirmiran, P., Bahadoran, Z., Golzarand, M., Rajab, A., Azizi, F. (2013). Ardeh (Sesamum indicum) Could Improve Serum Triglycerides and Atherogenic Lipid Parameters in Type 2 Diabetic Patients: A Randomized Clinical Trial, Arch Iran Med.16(11) 652 – 656.
19. Narasimhulu, C.A., Selvarajan, K., Litvinov, D., and Parthasarathy, S. (2015). Anti-Atherosclerotic and Anti-Inflammatory Actions of Sesame Oil, Journal of medicinal food, 18 (1), 11–20.
20. Ruckmani, A., Meti, V., Vijayashree, R., Arunkumar ,R., Konda, V.R., Prabhu, L., Madhavi, E., Devi, S. (2018). Anti-rheumatoid activity of ethanolic extract of Sesamum indicum seed extract in Freund's complete adjuvant induced arthritis in Wistar albino rats, Journal of Traditional and Complementary Medicine 8, 377-386.
21. Sadat, B.E., Haghighian, M.K., Alipoor, B., Mahdavi, A.M., Mohammad, A.J.M.A., Moghaddam, A. (2013). Effects of sesame seed supplementation on clinical signs and symptoms in patients with knee osteoarthritis, International Journal of Rheumatic Diseases,16: 578–582.
22. Selvarajan, K., Narasimhulu, C.A., Bapputty, R., and Parthasarathy, S. (2015). Anti-Inflammatory and Antioxidant Activities of the Nonlipid (Aqueous) Components of Sesame Oil: Potential Use in Atherosclerosis, Journal of medicinal food, 18 (4), 393-402.
23. Shamloo, M.B.B., Nasiri, M., Dabirian, A., Bakhtiyari, A., Mojab, F., Majd, H.A. (2015). The effects of topical sesame (sesamum indicum) oil on pain severity and amount of received non-steroid anti-inflammatory drugs in patients with upper or lower extremities trauma, Anesth Pain Med., 5(3): e25085.
24. Shamloo, M.B.B., Nasiri, M., Dabirian, A., Bakhtiyari, A., Mojab, F., Majd, H.A. (2019). Effects of topical sesame (Sesamum indicum) oil on the pain severity of chemotherapy-induced phlebitis in patients with colorectal cancer: A randomized controlled trial, Complementary Therapies in Clinical Practice 35, 78–85.
25. Shimizu, S., Ishigamori, R., Fujii, G., Takahashi, M., Onuma, W., Terasuki, M., Yano, T., Mutoh, M. (2015). Involvement of NADPH Oxidases in suppression of cyclooxygenase-2 promoter dependent transcriptional activities by sesamol, J.Clin.Biochem.Nutri 56 (2),118-122.

26. Suzuki, R., Fukami, S., Tomomura, M., Tomomura, A., Shirataki, Y. (2018). Screening for natural medicines effective for the treatment of osteoporosis, Journal of Natural Medicines.Retrieved from https://doi.org/10.1007/s11418-018-1258-y
27. Tachibana, R., Matsushita, H., Minami, A., Morita, N., Shimizu, S., Kanazawa, H., Suzuki, T., Watanabe, K., Wakatsuki, A. (2020). Dietary sesame diminishes bone mass and bone formation indices in ovariectomized rats, Clin. Exp. Obstet. Gynecol., 47 (4), 546-551.
28. Thuy, T.D, Phan, N.N, Wang, C.Y., Yu, H. G, Wang, S.Y, Huang, P.L, Do, Y.Y., Lin, Y.C. (2017). Novel therapeutic effects of sesamin on diabetes-induced cardiac dysfunction, Molecular Medicine Reports 15, 2949-2956.
29. Tricco, A.C., Lillie, E., Zarin, W., O'Brien, K.K., Colquhoun, H., Levac, D. (2018). PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med,169, 467–473.
30. Udomruk, S., Kaewmool, C., Phitak, T., Pothacharoen, P., and Kongtawelert, P. (2020). Sesamin Promotes Neurite Outgrowth under Insufficient Nerve Growth Factor Condition in PC12 Cells through ERK1/2
31. Pathway and SIRT1 Modulation, Evidence-Based Complementary and Alternative Medicine. Retrieved from https://doi.org/10.1155/2020/9145458
32. Yavari, M., Rouholamin, S., Tansaz, M., Bioos, S., Esmaeili, S. (2014). Sesame a Treatment of Menstrual Bleeding Cessation in Iranian Traditional Medicine: Results from a Pilot Study, Shiraz E-Med J. 15(3): e21893.
33. Yavari, M., Rouholamin, S., Tansaz, M., Esmaeili, S.(2016). Herbal Treatment of Oligomenorrhea with Sesamum indicum L.: A Randomized Controlled Trial, GMJ.5(3):114-121.
34. Zhou, L., Lin, X., Abbasi, A.M., Zheng, B. (2016).Phytochemical Contents and Antioxidant and Antiproliferative Activities of Selected Black and White Sesame Seeds, BioMed Research International, 8495630.Retrieved from http://dx.doi.org/10.1155/2016/8495630

Evaluation of the perceived palatability levels of grazing forages of wild asian elephants in Sri Lanka

U D Tharangi[1*], R U Halwathura[1] and S Somaratne[2]

Department of Civil Engineering, Faculty of Civil Engineering, University of Moratuwa, Sri Lanka[1].

Department of Botany, The Open University of Sri Lanka, Nawala, Nugegoda, Sri Lanka[2].

ABSTRACT

The relative preference of Asian elephants for particular plant species is one of the important factors in enhancing forage availability through elephant-specific conceptual conservation strategies in habitat enrichment to keep elephants inside fragmented landscapes. The dilemma posed by the human-elephant conflict and the loss of forage lands due to the burgeoning population density of Sri Lanka indicates the necessity of sustainable forage availability. The information on the palatability levels of forage plants of elephants grazing in Sri Lankan forests and lands is rare. Thus, the present investigation focused on the perceived palatability levels of forages consumed by wild elephants in distinct provinces in the country. An online, piloted, and validated questionnaire was conducted to gather information from respondents with field experience and expertise. The responders were chosen at random, and the questionnaire was administered. A list of palatable plant species was compiled based on the literature, field surveys, and interviews conducted with wildlife experts. Twenty-two common elephant fodder plants were identified from eight provinces on the island, including three herbaceous, 14 types of grass, and five sedges. The perceived palatability scores differ across the provinces, plant types, and species. Of the 22 listed forage plants, Pennisetum purpureum, Sacciolepis interrupta, Panicum maximum, and Echinochloa glabrescens surpass the rest, with relatively higher palatability scores. Thus,increasing the availability of forage plants with higher palatability levels secures and sustains the wild elephants in Sri Lanka. Further studies are required to understand the spatiotemporal variation of these plants entirely.

Keywords: Human-Elephant Conflict (HEC), Perceived Forage Palatability, Asian elephants, Wildlife Conservation, Sri Lanka.

INTRODUCTION

The Asian elephant (Elephas maximus), a member of the genus in the family Elephantidae, is widely distributed in South Asian and Southeast Asian countries (Gorade & Datar, 2014). In Sri Lanka, it has been reported that a total of ca. 5879 elephants, according to the Department of Wildlife Conservation (DWC) report (2011), have been spatially concentrated in the Mahaweli and Eastern regions(The Department of Wildlife Conservation, 2013; Insurance, 2019; Fernando et al., 2021). However, it has been reported that the elephant population was subjected to fluctuations through 1951 when there was an increase (1500 elephants in 1951). Since then, the elephant population has continuously increased to 1600-2200 in 1969, 2000- 4000 in 1978, and 5879 in 2011 (Fernando et al., 2011). The

tharangi.uyanahewa90@gmail.com

estimated elephant population in Sri Lanka in 2017 was ca. 6000, thus, 300,000 kg for their daily food requirement (Santiapillai et al., 2010).

As far as the island's human population is concerned, there has been substantial growth during the past ten years, and this substantial increase in the population has created unexpected pressure on the island's natural forests(Tharangi et al., 2022a). According to the literature about forest cover and forest cover changes, it has decreased from 82% in 1882 to 29.7% in 2017 (Ruzaik, 2021). Therefore, the existing forest cover is not supportive of feeding and providing habitats for the elephant population in the country. Meanwhile, based on the unpublished information available for 2021 at the Wildlife Department, the elephant deaths during 2010 – 2021 indicated a significant increasing trend with a total of 3181 deaths, while human deaths vice versa and accounted for 685. According to a recent IUCN status report, the Asian elephant has been included in the "Endangered" category (Fernando et al., 2021). The declining forest cover, associated with human population increase, has led to perpetual HEC.

The increase in forage availability would lead to minimizing the HEC. In this regard, identifying the plants that could be introduced into inaccessible lands is worthwhile. The grasses possess higher adaptability and regenerative capacity and thrive well in varying climatic conditions. Therefore, it is appropriate to increase the abundance of grazing grass availability.

The behavior of wild elephants causes several issues, centering around human death and injuries, property losses, crop losses, and social losses (LIFE, 2019). In addition, many incidents of human-induced damage to elephants have been reported, even leading to deaths (LaDue et al., 2021; De Silva et al., 2013). This situation is now referred to as the Human-Elephant Conflict (HEC). There are several migratory measures in practice, including the introduction of electric fences and trenching to restrict elephants' movement.

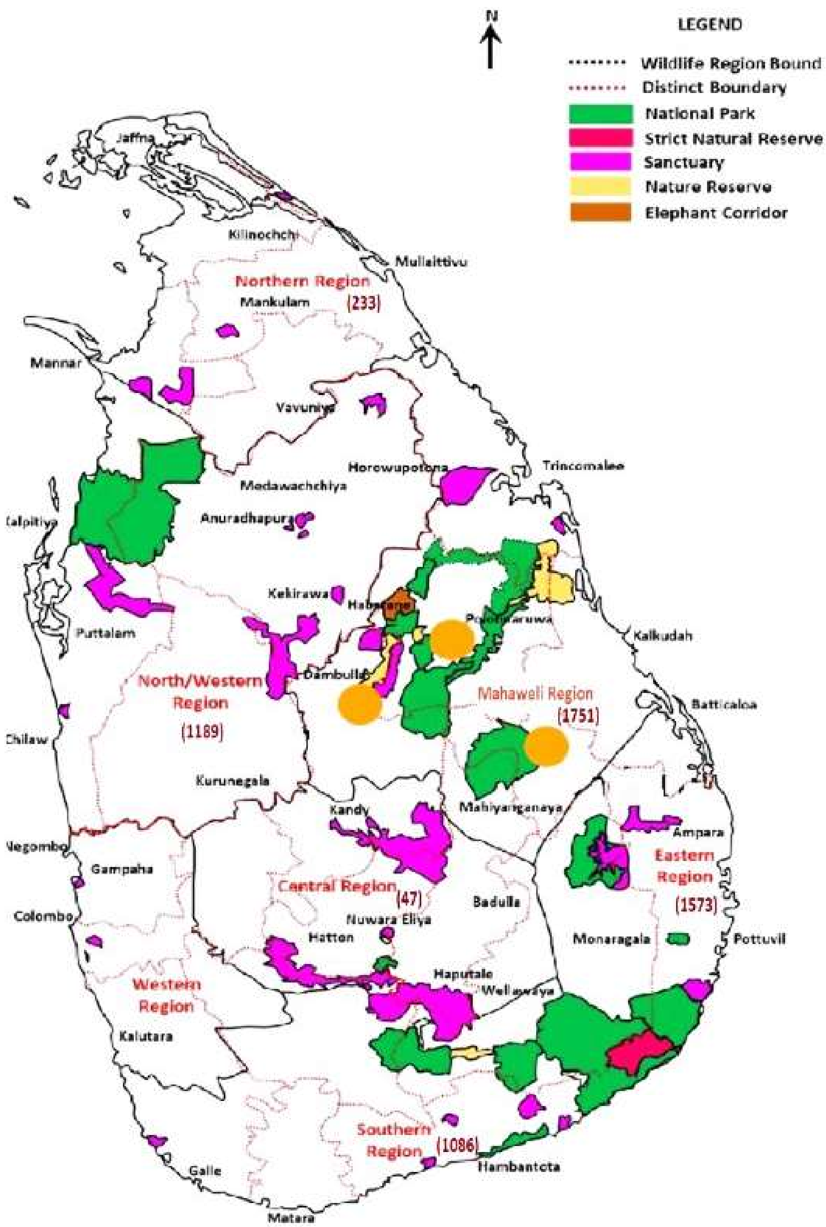

Figure 1. Distribution of elephants by Wildlife regions in Sri Lanka (Modified after Rajapakse et al., 2019).

However, HEC remains persistent as most existing prevention strategies driven by site-specific factors only offer short-term solutions, while mitigation strategies transfer conflict risk from one place to another (Shaffer et al., 2019). For a sustainable solution for the HEC, a holistic approach to the problem is essential, and the factors of basic needs such as water, food, and breeding sites are important in such endeavours (Skitka et al., 2011).Asian elephants, as mega-herbivores, are shown to consume a wide variety of vegetation, as many as 165 species of plants belonging to 56 families (Bhatt et al., 2011).

Therefore, identifying the palatability levels and preferences for each plant species is important in enhancing the habitat enrichment endeavours to mitigate human-elephant conflict (EHC) by avoiding the implementation of fences, including biological and electric, with unsustainable pressure on elephant behaviour (Bhatt et al., 2011; Krishnan & Braude, 2014).

Regarding feeding behaviour, feeding behaviours such as fodder palatability, availability, and nutrient requirement play a crucial role in finding migratory measures for the HEC (Nakano et al., 2020). Therefore, it is necessary to focus on the increase in the availability of grass fodder. It is a well-known fact that forage palatability is associated with physical characteristics such as fiber content, level of maturity, toughness, succulence, and leafiness, which can be determined by observing the forage intake of elephants. Further, forage palatability, availability of grass species, and the physiology of an animal were major factors influencing the relative preference (Stimulation, 2013; Gorade & Datar, 2014).The relative preference of Asian elephants for particular plant species is an important enhancing factor in forage availability through elephant-specific conceptual conservation strategies in habitat enrichment to keep elephants inside the fragmented landscapes. A comprehensive literature survey on the relative palatability level of wild range elephants for each grazing forage in Sri Lanka revealed that there was a scarcity of in-depth studies available on the feeding behaviour and diets of Asian elephants grazing on rangelands and secondary forests (Ashton et al., 1997; Samansiri & Weerakoon, 2007).

However, mitigating EHC through wild elephant management and enhancing habitat enrichment techniques requires a crucial understanding of feeding behaviour and ecology (Krishnan & Braude, 2014).For the survival of wild-range Asian elephants in fragmented landscapes through a habitat enrichment approach and co-existence strategy, an in-depth research is required to fill the gaps of knowledge about the relative preference of fodder plants of Asian elephants in the ranging forests in Sri Lanka (Kumar et al., 2010).

Therefore, the present study was carried out to evaluate the most palatable fodder species, which is part of ongoing research increase Asian elephant fodder availability based on the behaviour of wild elephants in elephant-ranging forest ecosystems. The study's findings would provide information for policymaking and implementing mitigatory measures for the ever-growing HEC. Further, the finding indirectly contributes to the reduction of economic losses as well as to conserve the elephant population in the country. For the survival of wild-range Asian elephants in fragmented landscapes through co-existence strategy, in-depth researches are required to fill the gaps of knowledge about the relative preference of forage plants of the Asian elephants in the ranging forests in Sri Lanka. Thus, this preliminary study aimed to evaluate the responder-rated palatability levels of selected herbaceous plants in relation to the distribution of the elephant population in Sri Lanka for the habitat enrichment approach.

METHODOLOGY

Sri Lanka, an island located southeast of the southernmost tip of the Indian subcontinent, lies between 5°55' and 9°51' northern latitudes, consisting of an approximate area of 65610 km2(Kumar et al., 2010). The present survey was conducted in the provinces where wild-elephant populations are, except in the Western Province (Figure 1).

As an initial step of the study, field visits were conducted during June–July 2021 in the Wilpattu, Ampara, Weli Oya, Mullaithivu, and Puttalam areas to select the sampling sites. Most of the responders encountered in the field visits, especially laymen such as farmers, mainly considered only the crops they cultivated. Therefore, responders were chosen based on knowledge of rangeland and interest in wild animals. During the field visits, an attempt was made to collect information on the wild plants preferred by wild elephants. Further, elephant-repellent plants were also noted during the visits but were not included in the study. A list of 22 herbaceous plants that were found in different provinces of the country was considered (Samansiri & Weerakoon, 2007; Djufri &Wardiah, 2017; Chathura & Perera, 2017), and the plant list was validated through a literature survey (Samansiri & Weerakoon, 2007).

Further, selected plants were confirmed as forages using secondary data and the taxonomic identity of the plants was determined by consulting relevant literature such as Townsend (1980; Cramer, 1981); Koyama, 1985; Clayton, 1994; Pedley & Rudd, 1996; Alahakoon et al., 2017; Samansiri & Weerakoon, 2007; and Ashton et al., 1997).The study employed the survey method in collecting information. A questionnaire was prepared and validated by subject experts, piloted, and validated. The validated questionnaire was converted into Google Form, an E-Based survey tool since the prevailing pandemic condition of the country precludes the field survey (Tharangi et al., 2023). The Google form was disseminated through emails and social media and follow-up by telephone communication during October-December, 2021. The questionnaire included 22 items with a 6-point Likert Scale viz. 0 = Unknown/ Not in this region,1 = Weekly palatable, 2 = Mild palatable, 3 =Moderately palatable, 4 = Strongly palatable and, 5 = Intensely palatable, as shown in Table 1(Joshi et al., 2015) and further responder's ratings of the Likert scale were converted into the scores by using weighted mean formula (Equation :1).

Table 1. Likert scale with responses.

Response	Scale
Intensely palatable	5
Strongly palatable	4
Moderately palatable	3
Mild palatable	2
Weekly palatable	1
Unknown/ Not in this region	0

An additional survey was also conducted from July 2021 to August 2021 to evaluate the questioner and assess errors and avoid confusion among respondents since rangers of the Wild Life Conservation Department and ecologists were interviewed from different regions of the country to make a list of-preferred herbaceous plant species by wild elephants (Alahakoon et al., 2017; Samansiri & Weerakoon, 2007; Gorade & Datar, 2014). Since the names of plant species are region-specific, the questionnaire was modified by attaching photographs of relevant plants, and vernacular names of each plant species were inserted into the questionnaire after getting feedback from most respondents. The data gathered through the survey was explored for errors and was subjected to descriptive and inferential statistical analysis. The responses to the items, except for zero values, were transformed into scores according to Equation (1) (Clark-Carter, 2010), and these scores were further converted into percentile values (Bodenham & Adams, 2016). The frequency distribution, mean, and standard deviation were calculated for the dataset. Further, analysis of variance was carried out using one-way analysis of variance (ANOVA) to compare the means. All the calculations and analyses were done through SPSS software (PC Ver. 26, IBM, 2019).

$Weighted\ Sum = \sum_{i}^{n}(xi * wi)$ - Equation (1).

Where,

*w*i = Weight assigned to the indication (Scale of Palatability Level)

*x*i = Number of responses for each indication (Field experts) (Clark-Carter, 2010)

RESULTS

The study included eight provinces of the country, and the common herbaceous plants grown in each province are listed in Table 2. The chosen list of plants includes 5 sedges, 3 herbaceous, and 14 grasses from different island provinces.

Table 2. Selected plant species and their families, with scientific names followed by common vernacular names.

Scientific Name	Family	Vernacular name §	Plant Type
Achyranthes aspera L.	Amaranthaceae	Gas Karalheba	Herb
Schoenoplectusgrossus (L.f.) Palla	Cyperaceae	Thunhiriya	Sedge
*Cyperus haspan*L.	Cyperaceae	Halpan	Sedge
Cyperus iria L.	Cyperaceae	Thunessa	Sedge
Cyperus rotundus L.	Cyperaceae	Kalanduru	Sedge
Fimbrisstylis miliacea (L.) Vahl	Cyperaceae	Mudu halpan	Sedge
Alysicarpus vaginalis(L.) DC	Fabaceae	Aswenna	Herb
Echinochloa colona(L.) Link	Poaceae	Gira thana	Grass
Echinochloa crusgalli(L.) Beauv	Poaceae	Wel marakku	Grass
Eleusine indica (L.) Gaertn.	Poaceae	Bela thana	Grass
Imperata cylindrica (L.) Beauv	Poaceae	Illuk	Grass
Isachne globose (Thunb.) Kuntze	Poaceae	Batadella	Grass

*Ischaemum timorense*Kunth	Poaceae	Rila thana	Grass
*Leersia hexandra*SW	Poaceae	Layu	Grass
*Panicum maximum*Jacq.	Poaceae	Gini thana	Grass
*Panicum repens*L.	Poaceae	Etora (Atawara)	Grass
*Echinochloaglabrescens*Kossenko	Poaceae	Bajiri	Grass
*Iachaemum rugosum*Salisb.	Poaceae	Gojarawalu	Grass
*Pennisetum purpureum*K. Schumach.	Poaceae	Ali maana	Grass
Sacciolepis interrupta(Willd.) Stapf	Poaceae	Beru	Grass
Dactyloctenium aegyptium(L.) Willd.	Poaceae	Putu thana	Grass
Bacopa monnieri(L.) Pennel	Scrophulariaceae	Lunuwila	Herb

§ - Sinhala

Present study limited the number of plant species due to available time, resources, labor and secondary data. The results obtained from the analyses were presented under the following themes: descriptive and inferential statistics.

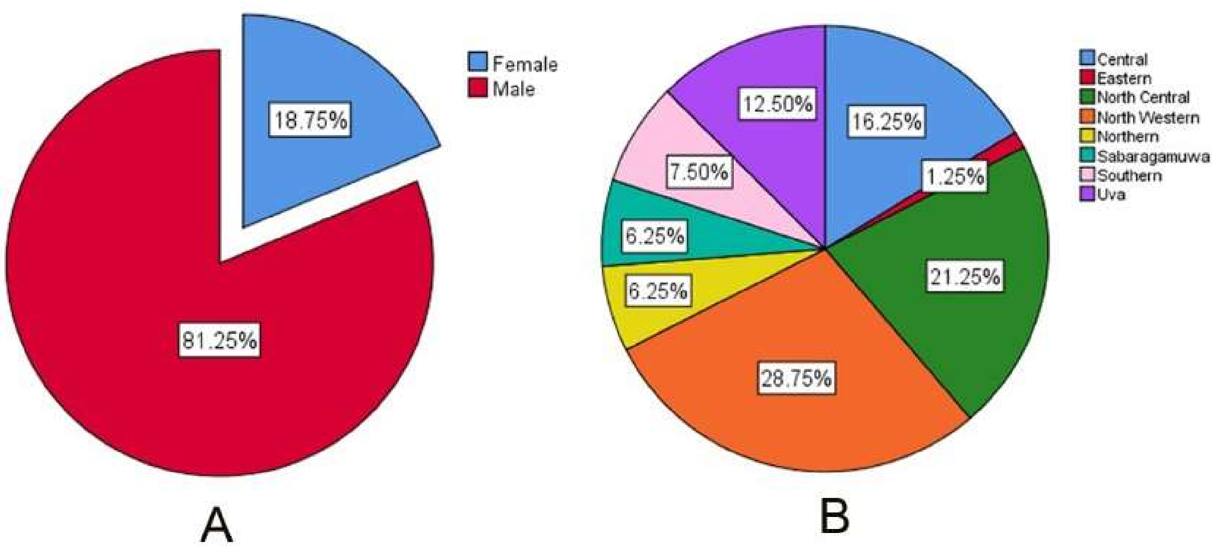

Figure 2. Distribution of responders' gender (A) and province (B) within the sample.

The distribution of gender in the total sample and the distribution of respondents by provinces are shown in Fig. 2, A, and B. Gender distribution in the total samples indicated less female participation (18.8%) in the field survey. In contrast, the majority of respondents were male (81.3%). The majority of responders were represented from the North Western Province (28.7%), North Central Province (21.3%), and Central Province (16.3%). The rest of the provinces were more or less equally represented in the sample and varied from 1.3% to 7.5%.The distribution of plants and their palatability levels in the different provinces is shown in Fig. 3 which represents the information in a dual-axis graph summarizing the variation of the palatability of plant species across different provinces.

According to the figure, there were certain plant species, such as *Sacciolepis interrupta* (Beru), which were highly preferred by wild elephants in the provinces, such as Eastern and North Central Provinces. Further, the plant's palatability level variation in the Southern and Sabaragamuwa Provinces is considerably lower than that of the rest of the provinces. Meanwhile, discernible within-province variation in the palatability level of the plant was also observed in the plants included in the study. Thus, plant palatability levels indicate a noticeable spatial variation across the provinces in the country.

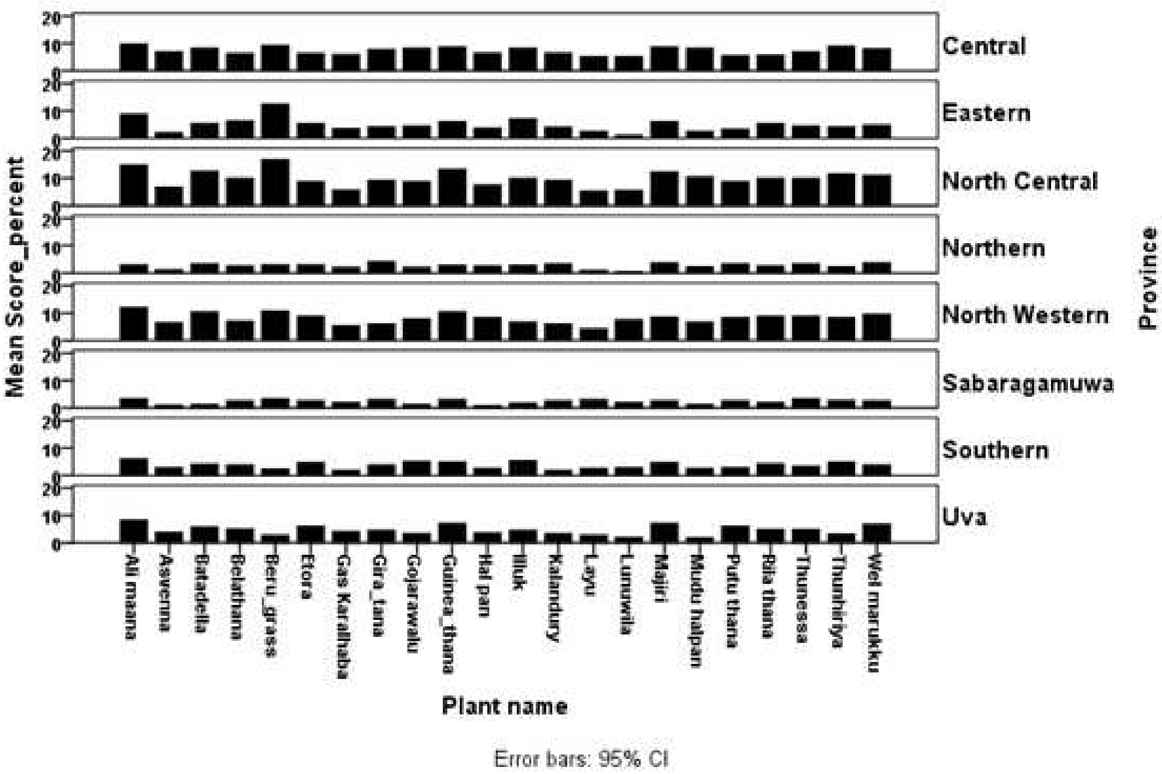

Figure 3. Distribution pattern of palatability level (Mean Score_percent) of plants by provinces.

The information in a dual-axis graph is represented in Fig.3 that summarizes the variation of the palatability of plant species across different provinces.

The distribution of the mean palatability score (expressed as %) among the plant species is shown in Table 3. The mean palatability scores of *Pennisetum purpureum* (Ali maana), *Sacciolepis interrupta* (Beru), and

Panicum maximum (Gini thana) were 8.22%, 7.5% and 7.0%, respectively. The mean palatability of a sub-set of plants, which included *Echinochloa glabrescens* (Bajiri), *Isachne globosa* (Batadella), and *Echinochloa crusgalli* (Welmarukku), fell within the mean palatability range of 6.6% - 6.25%. The mean palatability of *Imperata cylindrica* (Illuk) and *Schoenoplectus grossus* (Thunhiria) ranged from 5.78% to 5.72%. The rest of the fodder plants indicated low palatability percentages (4.56% -3.31%).

Table 3. Shows the averaged percentage palatability score among the elephant fodder plants collected in the study.

Plant name	Mean (%)	Std. Error
Pennisetum purpurerium (Ali maana)	8.22	1.44
Sacciolepis interrupta (Beru)	7.53	1.94
Panicum maximum (Ginithana)	7.00	1.30
Echinochloa glabrescens (Bajiri)	6.66	1.12
Isachne globose (Batadella)	6.34	1.35
Echinochloacrusgalli (Wel marukku)	6.25	1.08
Imperata cylindrica (Illuk)	5.78	0.98
Schoenoplectus grossus (Thunhiriya)	5.72	1.21
Panicum repens (Etora)	5.63	0.83
Cyperus iria (Thunessa)	5.56	0.94
Eleusine indica (Belathana)	5.41	0.90
Ischaemum timorense (Rila) thana	5.41	0.98
Echinochloa colona (Gira thana)	5.34	0.76
Iachaemum rugosum(Gojarawalu)	5.09	1.02
Dactyloctenium aegyptium (Putu thana)	5.03	0.88
Cyperus rotundus (Kalanduru)	4.56	0.88
Fimbrisstylis miliacea (Mudu halpan)	4.47	1.24
Cyperus haspan (Halpan)	4.41	0.95
Alysicarpus vaginalis (Asvenna)	3.84	0.88
Achyranthes aspera (Gas Karalhaba)	3.78	0.62
Leersia hexandra (Layu)	3.31	0.53
Bacopa monnieri (Lunuwila)	3.31	0.88

The variation of the average percentage palatability score across the type of elephant fodder plant is depicted in Fig. 4. According to the figure; the grasses surpass the rest of the plant types by having the highest palatability score (63.64%). The lowest palatability score was observed for the herbs (13.64%), and the palatability score of the sedges falls between the grasses and sedges.

The summary of the ANOVA is presented in Table 4. It indicates that there were significant differences in palatability scores (expressed as %), with the F-value associated with higher statistical significance ($F = 51.445$, $p < 0.05$).

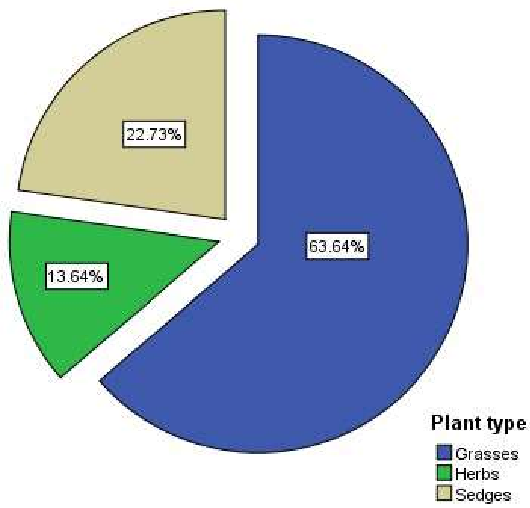

Figure 4. Variation of the palatability scores across by the plant types.

However, the plant variation was statistically insignificant ($F= 1.452$, $p > 0.05$).

Table 4. Summary of the Analysis of Variance (ANOVA) performed on the palatability levels across the provinces and plant species.

	Sum of Squares	**df**	**Mean Square**	**F ratio**	**Sig.**
Province					
Between Province	1158.568	7	165.510	51.445	0.000
Within Province	540.497	168	3.217		
Total	1699.065	175			
Plants					
Between plants	280.87	21	13.375	1.452	0.103
Within plants	1418.195	154	9.209		
Total	1699.065	175			

The sample included a higher number of male responders (81%) and a considerably lower number of female responders, and this may be due to the poor female participation in the workforce in the fieldwork in wildlife-related professions (Prakash et al., 2021). The difference between the responses and the gender of the responders did not vary considerably across the samples. This may be due to the higher representation of males as field experts in the sample population. The number of responders possibly indicated the respective extent of the wildlife-protected areas included in the study. For instance, Southern, Northcentral, Central, and Uva provinces represented higher numbers of responders and were 20%, 21%, 16%, and 13%, respectively. The Western Province has not been considered since the province does not include wild elephant range areas. The selected plant list included twenty-two elephant fodder plants, representing 3 herbaceous, 14 types of grass, and 5 sedges, mainly occurring in secondary forests, grasslands, and wetlands in the seven provinces. As far as plant types are concerned, there was a considerable difference in their distribution. The higher occurrence of grasses (64%) compared to sedges (23%) and herbs (14%)was reported in the study. This could be attributed to the fact that the grasses can distribute a wider range of ecological conditions and are much more resistant to drought than the sedges. Further, grasses often grow in association with marshland and inland water bodies and are adapted to periodic emergence and disappearance with the water availability fluctuation(Le Roux & Bariac, 1998; Wilcox et al., 2021). The spatial distribution of these plants indicates an ecological provenance and the occurrence of certain plants, such as Sacciolep is interrupta (Beru), which is more or less confined to the wetland of the drier areas, and the invasive grasses such as naturalized Panicum maximum (Ginithana), as widely distributed in the island irrespective of the climatic conditions. Further, the emergence of the plant species included in the study is associated with the prevailing climatic condition of the island, and much of the sedges and grasses growing in the wetland and the inland reservoirs are disappeared during the droughts and reappear in the rainy periods (Nawaz et al., 2014). Therefore, the availability of certain plant species under consideration indicated a seasonality. Thus, there was a spatiotemporal variation in the abundance of elephant fodder plants across the provinces than in others (Table 4).

Based on the perceived palatability levels, the following plants can be placed in descending order of palatability: Pennisetum purpureum (Ali maana) (8.22%), Sacciolepis interrupta (Beru) (7.53%), Panicum maximum (Gini thana) (7.00%), and Echinochloa glabrescens (Bajiri) (6.66%) (Table 3). However, the palatability of plant species could vary, which is governed by the prevailing climatic conditions of the area under consideration. Previous studies also support this finding (Le Roux & Bariac, 1998); (Kagan et al., 2019).Thus, elephants inhabited different provinces of the different climatic regions of the country may depend on the available plant species under different climatic conditions (Nawaz et al., 2014).

Further, the availability of such plant species directly or indirectly affects the roaming of elephants, aggravating the HEC and other socio-economic grievances of wild elephants. In this preliminary study, based on the available time, resources, and labor, it was decided to limit the number of plant species. But, many hundreds of plant species serve as elephant forages in accordance with literature and survey studies. The findings of this study can be used as a bases-line for future studies with an increased number of forage plants. In addition, diversification of particular elephant fodder plant species would sustain the availability of fodder plants irrespective of the seasonal variation of the climate. For instance, a mixture of forage plants, including drought-resistant and submerge-resistant, would effectively maintain year-round fodder availability (Tharangi et al., 2022b). Thus,fodder plants' availability and palatability levels secure and sustain the grazing forage for wild elephants in Sri Lanka.

CONCLUSION

Even though Sri Lankan elephants feed on a variety of fodder plants, higher perceived palatability scores were observed for Pennisetum purpureum (Ali maana), Sacciolep is interrupta (Beru), Panicum maximum (Gini thana), and Echinochloa glabrescens (Bajiri). Since the perceived patentability score of the fodder plant species represents the opinion of the respondents, the laboratory analyses, as well as field analyses of the selected grasses for their functional types, chemical composition, physical properties, and the variation of these properties with the soil and climatic parameters, are of importance in the determination of elephant forage preferences.

ACKNOWLEDGMENT

The authors wish to extend their sincere thanks to the Department of Wildlife Conservation, Sri Lanka, especially Deputy Director, Mr. Manjula Amararathne, Mr. Indika Abeysinghe Pathirana, Mr. Anil Vithanage (Udawalawa National Park), Mr. K Sujeewa Roshan (Yala National Park), Mr.Suranga Rathnayake (Wilpattu National Park), Mahaweli Authority Sri Lanka, Mr. U S Weerathunaga, (Udawalawe Elephant Research Project), for providing details, sharing their time and experiences.

REFERENCES

1. Alahakoon, A. M. D. B., Pushpakumara, E. M. A. B., Ellepola, G., & Ranawana, K. B. (2017). Food and feeding patterns of Asian Elephants in Udawalawe National Park, Sri Lanka. Gajah, 46(2017), 4–13. https://www.researchgate.net/publication/320857265
2. Ashton, Gunatilleke, Zoysa, Dassanayake, Gunatilleke, & Wijesundera. (1997). A Field Guide to the Common Trees and Shrubs of Sri Lanka. In WHT Publications (Pvt.) Ltd (Vol. 7, Issue November 2011).
3. Bhatt, P., Pradhan, N. M. B., & Wegge, P. (2011). Seed dispersal by megaherbivores: Do Asian elephants disperse Mallotus philippinensis, a main food tree in northern India and Nepal? Journal of Natural History, 45(15–16), 915–921. https://doi.org/10.1080/00222933.2010.538088
4. Bodenham, D. A., & Adams, N. M. (2016). A comparison of efficient approximations for a weighted sum of chi-squared random variables. Statistics and Computing, 26(4), 917–928. https://doi.org/10.1007/s11222-015-9583-4
5. Chathura, P., & Perera, D. (2017). Review of major abundant weeds of cultivation in Sri Lanka. February.
6. Clark-Carter, D. (2010). Measures of Central Tendency Interaction of radiation with matter Inferences for Two Populations. International Encyclopedia of Education.

7. Clayton. (1994). Poaceae. In M. D. Dassanayake (Ed.), A Revised Handbook to the Flora of Ceylon, V. VIII (p. 469). Amerind Publishing Co. Pvt. Ltd., New Delhi.
8. Cramer. (1981). Scrophulariaceae. In M. D. Dassanayake (Ed.), A Revised Handbook to the Flora of Ceylon, V. III (pp. 386–449). Amerind Publishing Co. Pvt. Ltd., New Delhi.
9. De Silva, S., Elizabeth Webber, C., Weerathunga, U. S., Pushpakumara, T. V., Weerakoon, D. K., & Wittemyer, G. (2013). Demographic variables for wild Asian elephants using longitudinal observations. PLoS ONE, 8(12). https://doi.org/10.1371/journal.pone.0082788
10. Djufri, & Wardiah. (2017). The diversity of undergrowth plants on Acacia nilotica stands as food resources of banteng (Bos javanicus) in baluran National park, East java, Indonesia. Biodiversitas, 18(1), 288–294. https://doi.org/10.13057/biodiv/d180138
11. Fernando, P., De Silva, M. K. C. R., Jayasinghe, L. K. A., Janaka, H. K., & Pastorini, J. (2021). First country-wide survey of the Endangered Asian elephant: Towards better conservation and management in Sri Lanka. Oryx, 55(1), 46–55. https://doi.org/10.1017/S0030605318001254
12. Fernando, P., Jayewardene, J., Prasad, T., Hendavitharana, W., & Pastorini, and J. (2011). Current status of Asian elephants in Sri Lanka. Gajah, 35(2011), 93–103.
13. Gorade, P. D., & Datar, M. N. (2014). Checklist of Palatable Grass Species from Peninsular India. Notulae Scientia Biologicae, 6(4), 441–447. https://doi.org/10.15835/nsb649376
14. Joshi, A., Kale, S., Chandel, S., & Pal, D. (2015). Likert Scale: Explored and Explained. British Journal of Applied Science & Technology, 7(4), 396–403. https://doi.org/10.9734/bjast/2015/14975
15. Kagan, I. A., Goodman, J. P., Seman, D. H., Lawrence, L. M., & Smith, S. R. (2019). Effects of Harvest Date, Sampling Time, and Cultivar on Total Phenolic Concentrations, Water-Soluble Carbohydrate Concentrations, and Phenolic Profiles of Selected Cool-Season Grasses in Central Kentucky. Journal of Equine Veterinary Science, 79, 86–93. https://doi.org/10.1016/j.jevs.2019.05.005
16. Koyama. (1985). C Y P E R A C E A E. In M. D. Dassanayake (Ed.), A Revised Handbook to the Flora of Ceylon, V. V (pp. 125–405). Amerind Publishing Co. Pvt. Ltd., New Delhi.
17. Krishnan, K., & Braude, S. (2014). Journal of the Asian Elephant Specialist Group. Gajah, 41(32), 3–11.
18. Kumar, M. A., Mudappa, D., & Raman, T. R. S. (2010). Asian elephant Elephas maximus habitat use and ranging in fragmented rainforest and plantations in the Anamalai Hills, India. Tropical Conservation Science, 3(2), 143–158. https://doi.org/10.1177/194008291000300203
19. LaDue, C. A., Eranda, I., Jayasinghe, C., & Vandercone, R. P. G. (2021). Mortality Patterns of Asian Elephants in a Region of Human–Elephant Conflict. Journal of Wildlife Management, 85(4), 794–802. https://doi.org/10.1002/jwmg.22012

20. Le Roux, X., & Bariac, T. (1998). Seasonal variations in soil, grass and shrub water status in a West African humid savanna. Oecologia, 113(4), 456–466. https://doi.org/10.1007/s004420050398
LIFE. (2019). Situational analysis report Sri Lanka (Issue July).
21. Nakano, T., Bat-Oyun, T., & Shinoda, M. (2020). Responses of palatable plants to climate and grazing in semi-arid grasslands of Mongolia. Global Ecology and Conservation, 24, e01231. https://doi.org/10.1016/j.gecco.2020.e01231
22. Nawaz, N., Javed, R., Hussain, K., Nawaz, K., & Majeed, A. (2014). Effect of Climatic and Soil Conditions on Guinea Grass (Panicum maximum (Jacq.) B.K) at Different Locations of Punjab, Pakistan. World Journal of Agricultural Sciences, 10(5), 231–242. https://doi.org/10.5829/idosi.wjas.2014.10.5.1825
23. Pedley and Rudd. (1996). Fabaceae. In M. D. Dassanayake (Ed.), A Revised Handbook to the Flora of Ceylon, V. X (pp. 149–198). Gulab Primlani, New Delhi.
24. Prakash, S. L., Samarakoon, G. V., Madurapperuma, B. D., Karunarathna, S., & Surasinghe, T. D. (2021). Defenders of Wildlife Conservation in Sri Lanka: a Cautionary Note for the Future of Rangers. Parks, 27(2), 57–62. https://doi.org/10.2305/IUCN.CH.2021.PARKS-27-2SLP.en
25. Rajapakse, R. P. V. J., Lawton, S. P., Karunathilake, K. J. K., Perera, B. V. P., Nguyen, N. T. B., & Le, T. H. (2019). Molecular characterization of Fasciola jacksoni from wild elephants (Elephas maximus maximus) of Sri Lanka: A taxonomic evaluation. Parasitology, 146(10), 1247–1255. https://doi.org/10.1017/S0031182019000519
26. Ruzaik, F. (2021). Analysis of possible scenarios for conserving forest cover in Sri Analysis of possible scenarios for conserving forest cover in Sri Lanka. June.
27. Samansiri, K. A. P., & Weerakoon, D. K. (2007). Feeding behaviour of Asian elephants in the Northwestern region of Sri Lanka. Gajah, 27(January 1998), 27–34.
28. Santiapillai, C., Wijeyamohan, S., Bandara, G., Athurupana, R., Dissanayake, N., & Read, B. (2010). An assessment of the human-elephant conflict in Sri Lanka. Ceylon Journal of Science (Biological Sciences), 39(1), 21. https://doi.org/10.4038/cjsbs.v39i1.2350
29. Shaffer, L. J., Khadka, K. K., Van Den Hoek, J., & Naithani, K. J. (2019). Human-elephant conflict: A review of current management strategies and future directions. Frontiers in Ecology and Evolution, 6(JAN), 1–12. https://doi.org/10.3389/fevo.2018.00235
30. Skitka, L. J., Aramovich, N. P., Lytle, B. L., & Sargis, E. G. (2011). The psychology of justice and legitimacy: The Ontario symposium. The Psychology of Justice and Legitimacy, 11(January), 1–350. https://doi.org/10.4324/9780203837658

31. Stubbs & Blundell. (2013). Appetite: Psychobiological and Behavioral Aspects. In Benjamin Caballero (Ed.), Encyclopedia of Human Nutrition (Third Edit). Academic Press. https://doi.org/doi.org/10.1016/B978-0-12-800259-9.00002-0
32. Tharangi, U. D., Halwathura, Rangika Umesh, Amarasekera, H. S., & Somaratne, S. (2023). The Perceived Palatability of Forage Plants of Wild Asian Elephants in Sri Lanka. 27th International Forestry and Environment Symposium, 20, 1–23. https://www.fesympo.sjp.ac.lk
33. Tharangi, U. D., Halwathura, R. U., & Somaratne, S. (2022a). Plant selection matrix for classifying elephant forage plants in Sri Lanka using metadata: A Cluster and Classification -and- Regression Tree Approach. Journal of the Sri Lanka Association for the Advancement of Science, 4(1), 17. https://doi.org/https://doi.org/10.5281/zenodo.7498120
34. Tharangi, U. D., Halwathura, R. U., & Somaratne, S. (2022b). Securing Elephants' Forage Availability in Inaccessible Ranges in Sri Lanka: An Innovative Grass Establishing Method. International Conference on Local Governance and Leadership, 1–155. https://doi.org/https://doi.org/10.6084/m9.figshare.21389067
35. The Department of Wildlife Conservation. (2013). The First Island Wide National Survey of Elephants in Sri Lanka :2011. The Department of Wildlife Conservation, Battaramulla, Sri Lanka.
36. Townsend. (1980). Amaranthaceae. In M. D. Dassanayake (Ed.), A Revised Handbook to the Flora of Ceylon, V. I (pp. 1–57). Amerind Publishing Co. Pvt. Ltd., New Delhi.
37. Wilcox, D. A., Bateman, J., Kowalski, K., Meeker, J., & Dunn, N. (2021). Extent of Sedge / Grass Meadow in a Lake Michigan Drowned-River-Mouth Wetland Dictated by Topography / Bathymetry and Lake Level Methods. 1–16.

I. GENERAL INSTRUCTIONS

1) Research presented in the manuscript could be in any field of science. 2) The research work should not have been published or submitted for publication elsewhere. 3) A corresponding author who will be responsible for all communications with the SLAAS Office should be identified. 4) Submission of manuscripts: Manuscripts can be submitted online https://journal.slaas.lk/. 5) Certificate of authenticity: Declaration form should be duly filled, signed by all authors and attach separately. 6) Submissions that involve human or animal trials should provide evidence of approval obtained by an ethics review committee.

II. SPECIFIC INSTRUCTIONS TO AUTHORS

1. Document to be submitted: Manuscript in MS Word format.

2. Format for typesetting
   - Paper size: A4 (210 x 297) typed single sided only.
   - Margins: Top, bottom and right margins of 25 mm and a left margin of 30 mm. 2
   - Line spacing: 1.5 (18 points) throughout the text.
   - Length: Length of the manuscript including text, tables, figures and references should not exceed 15 typed pages.
   - Page and line numbering: All pages should be sequentially numbered using Arabic Numbers. All lines should also be numbered sequentially starting from the top to the bottom of each page.
   - Font: Arial font, size 12. ! Language/spelling: UK English only.
   - Software: Authors may use either MS Word for Windows or the Macintosh equivalent.

3. Title Page: Title page should include the following Information;
   - Title and running title (less than 25 Characters). They should be in bold faced letters
   - Name/s and affiliation/s of author/s
   - Email address, mailing address and contact numbers of the corresponding author. Note: Identified the corresponding author by placing an asterisk after the name.

4. Abstract
   - Should be limited to a maximum of 250 words.
   - Up to a maximum of the five (05) key word should be identified, arranged in alphabetical order, included immediately after the abstract.
   - Abstract should be typed in italics. Scientific names in the abstract should be underlined.
   - No reference, tables, or figures should be included in the abstract.

5. Body
   - Introduction: Justification of the research work, objectives and hypotheses should be included in the introduction.
   - Methods and Materials/ Methodology: All materials, chemicals, clinical, subjects and samples used should be identified. Analytical, survey and statistical method should be explained concisely. Common analytical methods need not be elaborated.
   - Results and Discussion: Can be combined.
   - Conclusions: Should be concise.
   - Headings: All headings should be in bold capital and centered, e.g., INTRODUCTION
   - Subheadings: All subheadings should be in bold and in title case, e.g., Preparation of Land.
   - Non-English terms: All non-English terms should be italicized, e.g., et al., i.e., viz., except "etc."
   - References: Use APA style 3

6. Table and Figures
   - Should be included in the exact place within the text
   - Tables should be numbered sequentially using Arabic numerals. The titles should be self explanatory and placed above the tables.
   - Tabled should not contain any vertical lines
   - Illustration, Line drawing and photographs, if any, should be clear, properly numbered and captioned and ready for reproduction. They should be of high and resolution such as minimum of 300 dpi and saved in .tif or .bmp formats. Please do not use .jpeg or similar formats that do not reproduce well.
   - All lettering, graph lines and points on graphs should be sufficiently large and bold faced to permit reproduction for inclusion in the Journal.
   - Artworks and illustrations should be of appropriate thickness. Please note that thin lines do not reproduce well. Please note that the illustrations, line drawings and photographs should be placed in the appropriate location of the electronic file and numbered sequence with other figures.

7. Units
   - SI units should be used.
   - A single space should be left between the numerical value and the unit.

8. Acronyms and Abbreviations
   - All acronyms should be written in full at the first time of appearance. Abbreviations can be used subsequently.

- The full stop should not be included in abbreviations. Where abbreviations are likely to cause ambiguity or may not be readily understood by readers, the units should be mentioned in full.

9. On being informed of the acceptance, the manuscripts should be revised as per the reviewers' suggestions and re-submitted to the Editor – SLAAS. The accepted manuscripts will be published in the inaugural Journal of the SLAAS. Manuscripts that do not confirm to the above guidelines will not be accepted.
10. Acknowledgements Only the essential individuals and/or organizations/institutes should be include
11. Need to attach the manuscripts both as 1. with names and affiliations of the author and 2. Without with names and affiliations of the author

ISSN 1391-0256

Journal of the Sri Lanka Association for the Advancement of Science

Volume 5 Issue 1

Contents

Research Article

9771391025002

Edited and Published by the Sri Lanka Association of for the Advancement of Science

ISSN 1391-0256