ASURS 2025

Applied Sciences Undergraduate Research Sessions

ABSTRACTS

Applied Sciences Undergraduate Research Sessions

ASURS 2025

04th June 2025

Faculty of Applied Sciences

Rajarata University of Sri Lanka

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Message from the Vice Chancellor

It gives me great pleasure to extend my warmest congratulations to the Faculty of Applied Sciences as it prepares to host the seventh *Applied Sciences Undergraduate Research Sessions (ASURS)* in 2025.

Research has always been a cornerstone of academic advancement at the Rajarata University of Sri Lanka. The university remains steadfast in its commitment to fostering an environment that encourages systematic inquiry, intellectual engagement, and the broad dissemination of knowledge across diverse disciplines. By nurturing innovation and embracing a spirit of inquiry, we contribute meaningfully to the betterment of society while cultivating a scholarly culture rooted in critical thinking and evidence-based exploration.

I take particular pride in noting that alumni from the Faculty of Applied Sciences are among the top 2% of researchers globally - an achievement that speaks volumes about the calibre of our academic community. Undergraduate research plays a pivotal role in this ecosystem. It not only nurtures curiosity and a passion for discovery among students but also lays a strong foundation for their academic and professional development.

ASURS 2025 brings together a rich tapestry of perspectives from the fields of Physics, Mathematics, Health Promotion, Computing, Chemistry, and Biology. This interdisciplinary engagement underscores the faculty's academic strength and signals a forward-looking commitment to addressing contemporary challenges through research. I commend our undergraduates for their diligence and enthusiasm, and I deeply appreciate the mentorship and guidance provided by our academic staff throughout their research journeys.

The practice of providing students with opportunities to present their work in a scientific forum is a commendable one, as it builds confidence, sharpens communication skills, and fosters a sense of scholarly responsibility. I also encourage our students to share their findings beyond academic circles—to engage with the wider public and contribute to societal progress through informed dialogue and knowledge transfer.

I am sincerely grateful to the Dean, the faculty members, and the ASURS 2025 Organising Committee for their commitment, vision, and tireless efforts in bringing this event to fruition. Your collaborative spirit has significantly enriched the university's research culture and continues to elevate its academic profile.

To all the undergraduates presenting at ASURS 2025, I offer my heartfelt congratulations. I wish you an intellectually rewarding and enjoyable experience as you take part in this important academic milestone.

Dr. P.H.G. Janaka Pushpakumara

Acting Vice Chancellor

Rajarata University of Sri Lanka

Mihintale

Message from the Dean

It is with great pride and enthusiasm that I extend best wishes to the Applied Sciences Undergraduate Research Sessions (ASURS) 2025. This annual event, organized by the Faculty of Applied Sciences, Rajarata University of Sri Lanka, has grown into a vital platform for showcasing the intellectual curiosity, creativity, and scholarly rigor of our undergraduate students, predominantly those undertaking honours degree research projects.

This year, 66 students have contributed research abstracts spanning a wide range of disciplines: Biology, Computing and Information Technology, Chemical Sciences, Health Promotion, Mathematics and Statistics, and Physics. Their work reflects not only the depth of their academic engagement but also their commitment to addressing real-world challenges through scientific inquiry.

Undergraduate research is more than an academic exercise; it is a transformative process that shapes critical thinkers, problem solvers, and future leaders in Applied Sciences. The research abstracts included in this volume embody the students' dedication to excellence and the mentorship provided by our academic staff. In addition to the research sessions, ASURS 2025 also features a Three Minute Thesis (3MT) competition and a poster competition, providing students with the opportunity to communicate their findings concisely and creatively to a wider audience.

This year's sessions were organized by the Department of Physical Sciences, whose faculty and student team worked with great dedication and professionalism for over two months to deliver a highly successful event. Their efforts are deeply appreciated and reflect the collaborative spirit and high standards that define our faculty.

I extend my heartfelt congratulations to all student researchers and express my sincere gratitude to their academic supervisors. I also thank the organizing committee for their tireless work in bringing ASURS 2025 to life.

May this experience inspire our students to continue exploring, questioning, and innovating as they take their next steps in academia and beyond.

Dr. Manoj Fernando

Dean of the Faculty of Applied Sciences

Rajarata University of Sri Lanka

Mihintale

Message from the Chairperson

On behalf of the organizing committee, I extend my warmest greetings to all participants of 7th Applied Sciences Undergraduate Research Sessions (ASURS) - 2025 organized by the Faculty of Applied Sciences, Rajarata University of Sri Lanka. I am truly honored and delighted *to be the conference chair* of the ASURS - 2025.

ASURS, marks a significant milestone in the academic journey of our undergraduate students providing a platform to showcase their research findings and to contribute towards the growing body of knowledge in the field of Applied Sciences. It portrays high quality research conducted by the undergraduates under the supervision of internal and external senior academics and eminent researchers in collaboration with other Universities and prestigious research institutes. The number of presenters in ASURS has been increasing over the years and there are sixty six oral presentations by the final year students of B Sc (honours) degree programs and sixty two poster presentations by the final year students of B Sc degree programs, this year, in the fields of Biological Sciences, Chemical Sciences, Computing, Health promotion, Mathematics and Physics. In connection with the ASURS - 2025, a 3MT competition where thirty five presenters participated was organized to help improve the presentation and research communication skills to effectively explain their research in three minutes, in a language appropriate to a non-specialist audience. In addition, a creative art competition on the theme "Tree of Science" was also organized for all first, second and third year students to recognize and encourage the artistic talents of students.

This event would not be possible without the leadership and the guidance of Dr. Janaka Pushpakumara, the Acting Vice Chancellor of the Rajarata University of Sri Lanka. The cooperation rendered by Dr Manoj Fernando, the Dean of the Faculty of Applied Sciences was instrumental in navigating the challenges faced by the organizing committee throughout this endeavour. I wish to thank all the Heads of Departments and my fellow academic staff members, Assistant Registrar, Assistant Bursar and all non - academic staff members of the Faculty who contributed in numerous ways to make this event a great success. The keynote speaker Dr. Jinendrika A Weliwita, abstract reviewers, and panelists are also greatly acknowledged for their time and voluntary services, without which this event would not have been a reality. Further, my sincere thanks go to all the presenters and their supervisors for contributing their work to ASURS - 2025. It is noteworthy that the well- structured and supportive organizing committee of ASURS – 2025 was pivotal for the success of this event. My sincere thanks also go to all the sponsors ranging from local businesses to leading financial institutes of Sri Lanka for their generous financial support extended to make this event even more enriching and memorable.

I wish all the budding researchers of the Faculty of Applied Sciences a bright research career!

Dr. Uthpala Dahanayake

Chairperson

ASURS – 2025

Profile of the Keynote Speaker – Prof. Chathuranga Bamunuarchchige

Professor Chathuranga Bamunuarachchige is a well-accomplished, senior academic and researcher in the field of Biotechnology. He is currently serving as the Dean of the Faculty of Technology at the Rajarata University of Sri Lanka. With a strong academic foundation in Molecular Biology and Biotechnology, he has contributed extensively to both teaching and research in these areas. Prof. Bamunuarachchige earned his Ph.D. from the University of Peradeniya and has been a member of the Working Committee on Biotechnology and Bioethics of the National Science Foundation (NSF) in Sri Lanka.

He is a certified tutor mentor trainer in distance and continuing education. He has supervised several postgraduate students in the fields of Microbial Biotechnology and Molecular Biology. His teaching portfolio includes a range of undergraduate and postgraduate courses such as Molecular Biology, Molecular Biotechnology, Scientific Writing, and Molecular Microbiology.

Professor Bamunuarachchige's academic excellence has been recognized through several prestigious awards, including the Vice Chancellor's Award for Most Outstanding Senior Researcher and publishing highest number of articles in indexed journals for the Faculty of Technology. He was also a recipient of the Dr. A.W.R. Joachim Memorial Award for Best GPA. His research work, particularly in molecular biotechnology and plant pathology, has been widely acknowledged, and he has been involved in reviewing manuscripts and research proposals for national institutions such as the NSF and NRC. Prof. Bamunuarachchige is a certified peer reviewer under the Elsevier Researcher Academy and has served as a Reviewer for twelve WoS journals. He is also an Editorial Board member of the Journal of Food Research International, Elsevier. His research mainly involves microbial biotechnology with a special focus on commercially important agricultural and industrial applications such as biopesticides, bioinoculants, thermostable enzymes, and composite material.

As a member of the American Association for the Advancement of Science (AAS) and an invited reviewer for high-level scientific and innovation panels, Prof. Bamunuarachchige continues to play an active role in advancing science, both nationally and internationally.

Abstract of the Keynote Speech

Fungal Biotechnology; new avenues

(Thushara Chathuranga Bamunuarachchige, Professor in Biotechnology, Rajarata University, Sri Lanka)

Fungi have been heavily used in the production of food and beverages, biofertilizers, biopesticides, industrial enzymes, and antibiotics. However, with the introduction of novel technologies that possess high-throughput capabilities, there is a big emphasis for novel products in fungal biotechnology. With the developments in molecular life sciences, these technologies have been facilitated by new integrated “omics” approaches. The omics approaches have overcome some of the conventional challenges of microbial biotechnology, such as identification of mixed and unculturable strains, genetic variants, understanding complex pathways, and signaling processes in inter-species interactions. As examples, identifying an important group of fungi with higher lipid content has the potential of using it in the biodiesel industry, and the metagenomic-based identification of fungal microbiomes may pave the way for more efficient bioinoculants in mushroom culture and biofertilizers. In addition to these developments, the new sequencing technologies have resulted in venturing into unusual fungal niches including caves, cold and saline environments including glaciers, saline microbial mats, salt flats, and salterns. Due to the uniqueness and the prevailing stresses of these environments, such attempts have led to the widening of the arsenal of new fungal strains, enzymes, and metabolites which can be heavily used in fungal biotechnology.

Members of the Oral Presentation Evaluation Panels

Applied Biology

Prof. A.R.S.B. Athauda, Department of Animal Sciences, Faculty of Agriculture, University of Peradeniya, Peradeniya.

Prof. K.M.G. Gehan Jayasuriya, Department of Botany, Faculty of Biological Sciences, University of Peradeniya, Peradeniya.

Dr. D.R.G.W.B. Ellepola, Department of Zoology, Faculty of Science, University of Peradeniya, Peradeniya.

Microbiology

Prof. Chathuranga Bamunuarachchige, Department of Bioprocess Technology, Faculty of Technology, Rajarata University of Sri Lanka, Mihintale.

Dr. Ajith Rathnayake, Department of Bioprocess Technology, Faculty of Technology, Rajarata University of Sri Lanka, Mihintale.

Dr. K. Rasanie E. Padmathilake, Agricultural Engineering and Soil Science, Faculty of Agricuture, Rajarata University of Sri Lanka.

Chemistry

Dr. R.J.K. Udayana Ranatunga, Faculty of Science, University of Peradeniya, Peradeniya.

Dr. H.A. Naveen Dharmagunawardhane, Department of Materials Technology, Faculty of Technology, Rajarata University of Sri Lanka, Mihintale.

Ms. P.D.T.S. Niroshani Jayasundara, Department of Chemical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka.

Computing

Dr. P.R.H.N.G. Thilakarathna, Department of Information Communication Technology, Rajarata University of Sri Lanka, Mihintale.

Mr. P.G. Munasinghe, Department of Information Systems, Faculty of Management Studies, Rajarata University of Sri Lanka, Mihintale.

Mr. H.K.G.M.N. Karunarathne, Department of Information Systems, Faculty of Management Studies, Rajarata University of Sri Lanka, Mihintale.

Health Promotion

Prof. Kosala Weerakoon, Department of Parasitology, Faculty of Medicine and Allied Sciences, Rajarata University of Sri Lanka, Saliyapura, Anuradhapura

Prof. N.K. Anjana Silva, Department of Parasitology, Faculty of Medicine and Allied Sciences, Rajarata University of Sri Lanka, Saliyapura, Anuradhapura.

Mathematics

Dr. Udeni D. Wijesooriya, Department of Mathematics, Faculty of Science, University of Peradeniya, Peradeniya.

Dr. M.T.M. Dewasurendra, Department of Mathematics, Faculty of Science, University of Peradeniya, Peradeniya.

Dr. N. Varathan, Department of Mathematics and Statistics, Faculty of Science, University of Jaffna, Jaffna.

Physics

Prof. N.G.S. Shantha Gamage, Professor in Physics, Department of Physics, University of Sri Jayawardhanapura, Nugegoda.

Dr. Lakmal Jayarathne, National Institute of Fundamental Studies, Kandy.

Mr. S. Kuhanesan, Department of Physical Science, Faculty of Applied Science, University of Vavuniya, Vavuniya.

Members of the Poster Presentation Evaluation Panels

Biology

Dr. Prasad Tharanga Jayasooriya, Department of Bioprocess Technology, Faculty of Technology, Rajarata University of Sri Lanka, Mihintale.

Dr. Asha Wijegunawardhana, Department of Bioprocess Technology, Faculty of Technology, Rajarata University of Sri Lanka, Mihintale.

Dr. H.K.S. De Zoysa, Department of Bioprocess Technology, Faculty of Technology, Rajarata University of Sri Lanka, Mihintale.

Chemistry

Dr. Kalpani Kumari, National Institute of Fundamental Studies, Kandy.

Dr. Lakmal Jayarathne, National Institute of Fundamental Studies, Kandy.

Computing

Dr. H.M.B.P. Ranaweera, Department of Information Systems, Faculty of Management Studies, Rajarata University of Sri Lanka, Mihintale.

Mr. T.U.S. Senerath, Department of Information Systems, Faculty of Management Studies, Rajarata University of Sri Lanka, Mihintale.

Mrs. L.N.A.B.M. Nissanka, Department of Information Technology, Faculty of Social Sciences and Humanities, Rajarata University of Sri Lanka, Mihintale.

Health Promotion

Prof. Kosala Weerakoon, Department of Parasitology, Faculty of Medicine and Allied Sciences, Rajarata University of Sri Lanka, Saliyapura, Anuradhapura.

Prof. N.K. Anjana Silva, Department of Parasitology, Faculty of Medicine and Allied Sciences, Rajarata University of Sri Lanka, Saliyapura, Anuradhapura

Mathematics

Dr. M. Kayanan, Department of Physical Sciences, Faculty of Applied Sciences, University of Vavuniya, Vavuniya.

Mr. N. Edwin Linosh, Department of Physical Sciences, Faculty of Applied Sciences, University of Vavuniya, Vavuniya.

Physics

Dr. Kalpani Kumari, National Institute of Fundamental Studies, Kandy.

Dr. Lahiru Jayasuriya, Department of Electrical and Electronic Technology, Faculty of Technology, Rajarata University of Sri Lanka, Mihintale.

APPLIED BIOLOGY

AQUACULTURE POTENTIAL OF *Labeo heladiva*: BREEDING, EMBRYOGENESIS AND LARVAL MANAGEMENT

R.B.M.G.N. Bandara[1]*, T.V. Sundarabarathy [1] and A.R. Mudalige[2]

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
[2]National Aquaculture Development Authority (NAQDA), National Aquaculture Development Center, Dambulla, Sri Lanka.
**nayanajith9829@gmail.com*

Labeo heladiva (Teleostei: Cyprinidae) is slow-growing, endemic minor cyprinid species in Sri Lanka with potential as a sustainable nutrient option to combat malnutrition within the country. This study aimed to investigate its feasibility of induced breeding, document the stages of embryonic development, and assess the growth and survival of postlarvae reared under different captive conditions as there is no existing literature regarding these aspects. Broodstock of *L. heladiva* were collected from Janaranjana Wewa, Kantale, Eastern province of Sri Lanka. Induced breeding was conducted using synthetic hormone, Ovulin® (sGnRHa + Dompeidone). Female brooders were administrated three hormone doses *viz.*, 0.5, 0.4, 0.3 mL/kg while male received 0.25 mL/kg. A 1:1 male to female ratio was used for the breeding trials, each conducted in triplicate. Embryonic and larval development stages were observed and recorded up to 75 hours of post-egg release at average water temperature of 26.5˚C. Postlarvae were reared under three different conditions at a stocking density of 12 larvae/10L: jars (E1), hapa in a mud pond (E2), and a combined method where larvae were first reared in jars for one week and then transferred to hapa for two weeks (E3). Each treatment was replicated three times and conducted for period of three weeks. All hormone dosages resulted in successful spawning within a latency period of 9–10 hours. The highest average egg count (120,825 ± 2875.20) was recorded with the 0.5 mL/kg dosage, while the lowest (59,070 ± 1753.80) was observed with the 0.3 mL/kg dosage. The eggs of *L. heladiva* hatched at 28 hours, while the embryogenesis is completed by 25 hours. The hatchlings fully absorbed the yolk sac by 75 hours. A negative allometric growth pattern was observed among postlarvae in all experiments. The highest mean weight gain, relative growth rate (RGR-W), and specific growth rate (SGR-W) were observed in the hapa-reared larvae (E2), whereas the lowest was found in jar-reared larvae (E1) ($P < 0.05$). However, the growth parameters for larvae from combined method (E3) were not significantly different from either E1 or E2 ($P > 0.05$). The highest survival rate was recorded in jar (E1) and combined method (E3), which were significantly differ ($P < 0.05$) from those in hapa (E2). In conclusion, the successful captive breeding of *L. heladiva* can be achieved with 0.5, 0.4, 0.3 mL/kg doses using Ovulin®. The use of 0.5 mL/kg Ovulin® for breeding, together with the combined (E3) larval rearing method, ensures optimal growth and survival in *L. heladiva*, supporting its viability for aquaculture expansion.

Keywords: *Induced spawning, Hatchery jars, Hatchability, Cages, Growth performance, Survival rate*

INDUCED BREEDING AND EVALUATION OF SUITABLE FEED FOR LARVAL REARING OF THE ENDEMIC FISH *Mystus nanus* (SUDASINGHE, PETHIYAGODA, MADUWAGE & MEEGASKUMBURA, 2016)

P.S.N. Darshanie[1]*, T.V. Sundarabarathy[1] and A.R. Mudalige[2]

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
[2]National Aquaculture Development Authority (NAQDA), National Aquaculture Development Center, Dambulla, Sri Lanka.
**nadeejadarshanie@gmail.com*

The striped dwarf catfish, *Mystus nanus*, recently recognized as an endemic species of Sri Lanka, is the focus of a study aimed at enhancing its conservation through captive breeding programs. This research evaluates the most effective hormone for inducing breeding and the optimal feed for larval rearing. A total of 27 males and 13 females were collected from the Kala Oya spill, North Central Province of Sri Lanka. They were fed with commercial feed for tropical fish (protein content 42%) ad libitum. After a month of acclimatization, the broodstock were used for induced breeding trials with a male-to-female sex ratio of 2:1. Three hormone treatments were tested, each with three replicates: Ovulin (sGnRH analogue + domperidone), LHRHa + domperidone, and HCG, with natural breeding serving as the control. Ten-day-old postlarvae were randomly assigned to four different dietary treatments with at a stocking density of 2 postlarvae/L (50 postlarvae /tank); soya yogurt, *Artemia nauplii*, microworms, and commercial feed (control), with three replicates for each treatment. All three replicates of the Ovulin treatment successfully induced spawning, while only one replicate each of the LHRHa + domperidone and HCG treatments led to successful spawning. Natural spawning did not occur during the one-month period. No significant differences ($P > 0.05$) were observed among the hormone treatments in terms of total eggs spawned, relative fecundity, fertilization rate, hatchability, and survival rate. The latency period varied across treatments: Ovulin (8–10 hours), LHRHa + domperidone (9–11 hours), and HCG (6–8 hours). Fry fed soya yogurt showed the best growth performance, with final length of 24.70 ± 0.17 mm, final weight of 178.50 ± 2.31 mg, weight gain of 173.96 ± 2.58 mg, length gain of 17.50 ± 0.19 mm, SGR-W of 12.46 ± 0.27 % per day, SGR-L of 4.11 ± 0.03 % per day, and survival rate of 78.33 ± 0.88 %. In contrast, the lowest growth and survival were recorded in fry fed with microworms ($P < 0.05$), with final weight of 50.36 ± 1.43 mg, final length of 15.13 ± 0.02 mm, weight gain of 45.90 ± 1.36 mg, length gain of 7.97 ± 0.25 mm, SGR-W of 8.04 ± 0.08 % per day, SGR-L of 2.49 ± 0.05 % per day, and survival rate of 25.67 ± 1.20 %. The length–weight relationship analysis indicated that fish fed with soya yoghurt exhibited isometric growth ($b = 3$). It is recommended that the use of Ovulin hormone at a dosage of 0.5 mL/kg body weight in females is more effective for inducing breeding. Furthermore, soya yogurt has been identified as the most effective feed for larval rearing under captive breeding conditions. These practices are expected to be adopted for the conservation of *M. nanus*.

Keywords: *Hormone, Growth, Spawning, Survival, Soya yoghurt, Ovulin*

HERPETOFAUNAL SPECIES RICHNESS, DIVERSITY AND ABUNDANCE IN DIFFERENT HABITAT TYPES IN ENDANE BIODIVERSITY CORRIDOR, RATNAPURA DISTRICT, SRI LANKA

M.P.R.D. Dharmappriya[1]*, T. Abayarathna[1] and S. Wickramasinghe[1]

[1]Department of Biological Science, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
**rashmi.darmapriya99@gmail.com*

The Endane Biodiversity Corridor (EBC), located in the Ratnapura District of Sri Lanka, serves as a reforestation initiative, connecting the fragmented Iharakanda and Walankanda forest reserves. Recently, the concept of biological corridors has gained significant attention due to its practical, evidence-based benefits. These corridors are designed to enhance connectivity between protected areas and fragmented habitats. Given this, the current study sought to assess herpetofaunal (amphibians and reptiles) species abundance, richness and diversity across different habitat types within the corridor and adjacent Walankanda Forest Reserve. Four habitat types were surveyed from the beginning of July to the end of January 2025: the restored area, productive tea area, home gardens within the corridor and forested habitat in the Walankanda Forest Reserve (WFR). Data were collected using line transects, pitfall traps and opportunistic surveys covering both diurnal and nocturnal periods. Diversity indices were used to evaluate ecological diversity, and statistical analyses using a linear mixed effect models were conducted to compare species composition between habitats. The Sørensen similarity index was used to measure the similarity in species composition between different habitat types. A total of 39 herpetofaunal species was recorded, including 16 amphibians and 23 reptiles, with high levels of endemism (81% in amphibians and 58% in reptiles) and six amphibian (Bufonidae, Dicroglossidae, Ranidae, Rhacophoridae, Nyctibatrachidae and Ichthyophiidae) and eight reptile (Agamidae, Scincidae, Gekkonidae, Colubridae, Natricidae, Elapidae, Viperidae and Varanidae) families observed. The highest number of amphibian species was recorded from the family Rhacophoridae, while reptile species richness was greatest for the family Colubridae. The most abundant amphibian species was *Minervarya agricola* (Jerdon, 1853). The most abundant reptile species was *Calotes calotes* (Linnaeus, 1758). Among the four habitat types studied, the highest amphibian and reptile diversity was recorded in Walankanda Forest Reserve. The lowest amphibian diversity was observed in the productive tea area, while the restored area showed higher amphibian species richness compared to the home garden. The home garden had the lowest reptile diversity across all indices, most likely due to human disturbance, while the restored area exhibited moderate diversity, indicating partial recovery. According to the Sorensen dissimilarity matrices, the highest dissimilarity was recorded between natural forest and modified habitats, with greater similarity between anthropogenic areas like productive tea area and home garden. Habitat comparisons within the Endane corridor revealed that marginal tea areas exhibited the highest amphibian diversity and species richness, while productive tea areas had the lowest diversity and species richness. Woodland 2 had the highest reptile diversity, likely due to its proximity to Walankanda Forest Reserve. The findings emphasize the importance of reforested habitats in maintaining herpetofaunal diversity and highlight the ecological significance of the Endane Biodiversity Corridor in species conservation and habitat connectivity.

Keywords: *Reforestation, Herpetofauna, Abundance, Richness, Diversity, Indices, Endemism*

Acknowledgments: The authors are grateful to Dr Nalaka Geekiyanage, Senior Lecturer in the Department of Plant Sciences, Faculty of Agriculture, Rajarata University of Sri Lanka; the Franklinia Foundation, Switzerland; and Dilmah Conservation, Dilmah Ceylon Tea Company, Sri Lanka for their generous financial support.

BIRD ASSOCIATIONS WITH THREE *Ficus* SPECIES IN A SELECTED SITE IN PADIYATHALAWA, AMPARA

J.M.H.E. Gunarathna[1] and W.M.G.A.S.T.B. Wijetunga[1]*

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
**asanga@as.rjt.ac.lk*

Ficus species are recognized as keystone plant resources in tropical ecosystems due to their fruit availability throughout the year, supporting a wide variety of bird species. This study investigated the bird associations of selected *Ficus* species in Padiyathalawa, Ampara District, Sri Lanka and was conducted from September 2024 to February 2025. The research was conducted along three 1-km transects established on footpaths within the study area. Plots of 10×10 m were established along each transect line to identify and count *Ficus* trees using a field guide. Based on abundance and distribution, three *Ficus* species were selected: *Ficus religiosa*, *Ficus racemosa* and *Ficus benghaensis*. One tree from each species was randomly chosen along each transect, making a total of nine sampling locations. Bird observations were conducted from 06:30 to 09:30 hours, over 5 days during the fruiting season and 5 days during the non-fruiting season using the scan sampling method, with the help of a pair of 8×42 Pentax binoculars. Each tree was divided into three vertical strata (lower, middl, and upper) to examine vertical bird distribution. Birds were identified using a field guide. Number of bird species, abundances of individual species and their associations with the tree were recorded. A total of 2,273 individual birds representing 32 species from 22 families was recorded. The highest number of bird species was recorded on *F. religiosa* (27), followed by *F. racemosa* (22) and *F. benghalensis* (15). The highest number of bird visits was also recorded on *F. religiosa* (993), followed by *F. benghalensis* (821) and *F. racemosa* (458). Bird abundance was not significantly different among the three *Ficus* species (P = 0.2086). The highest similarity in bird communities was between *F. racemosa* and *F. religiosa* (Morista–Horn Index = 0.845). The values of Margalef's Index, Simpson Index and Shannon–Weiner Diversity Index were 2.086, 0.7479 and 1.85 for *F. benghalensis*; 3.428, 0.8491 and 2.311 for *F. racemosa*; and 3.768, 0.8011 and 2.057 for *F. religiosa*, respectively. Various bird interactions such as feeding, resting and nesting were observed and these were not significantly different among the three *Ficus* species (P = 0.925). These findings showed the ecological importance of *Ficus* species in supporting bird diversity. Agricultural expansion and unplanned development projects were identified as key threats to these *Ficus* species. Promoting the planting of these *Ficus* trees in disturbed landscapes and increasing community awareness are recommended to conserve bird diversity.

Keywords: *Ficus religiosa, Ficus racemosa, Ficus benghalensis, Keystone resources, Bird associations*

ASSESSMENT OF ARTHROPOD DIVERSITY IN PADDY FIELDS AND ASSOCIATED WEED PATCHES IN THE KANDY DISTRICT, SRI LANKA

Y.G.W.S. Jayamanna[1]* and D.K. Hettiarachchi[1]

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
**sulochanajayamanna@gmail.com*

Arthropods form a crucial component of agricultural ecosystems, playing essential roles as herbivores, predators, parasitoids and pollinators. Their interactions contribute to important ecological processes such as pest control, pollination and nutrient cycling. Paddy fields and surrounding weed patches provide distinct but interconnected habitats that vary in structure, plant composition and microclimatic conditions. These differences influence the composition and abundance of arthropods, especially during the different growth stages of rice, ranging from seedling vegetative stages through to flowering and ripening. Weed patches, which often harbour higher plant diversity and offer refuge throughout the cultivation period, can serve as significant reservoirs for arthropod biodiversity. This preliminary study explores the diversity and distribution of arthropods in paddy fields and adjacent weed patches across four sites Pamunuwa, Hepana, Gangoda and Lankathilaka in the Kandy District of Sri Lanka during the Maha season that extended from October 2024 to February 2025. Arthropods were sampled using sweep netting, quadrat sampling and pitfall trapping methods, while weed density was assessed using quadrat sampling. Across all sites, the study recorded arthropods belonging to 8 different orders, 59 families and 99 genera. The sampled arthropods were categorized into four functional groups based on their ecological roles. The study revealed that arthropod diversity and abundance were significantly higher in weed patches compared to paddy fields, with weed patches recording 99 species and 7,512 individuals *vs* 78 species and 6,519 individuals in paddy areas. Hemiptera (24%) and Coleoptera (21%) were the most dominant orders, while predator groups like Araneae and Odonata showed notable presence, particularly in weed habitats. Functional group analysis showed a higher representation of herbivores and predators in weed patches, supporting greater ecological roles. Paddy field growth stages also influenced arthropod presence, with pests like planthoppers and grasshoppers increasing in vegetative and reproductive phases, and predator abundance rising in later stages. Diversity indices such as the Shannon (3.849), Simpson (0.9697) and Margalef (10.98) indices were consistently higher in weed ecosystems, indicating that weed patches support a more complex and balanced arthropod community structure than managed paddy fields. This study showed that the heterogeneous diversity of plants has an effect on arthropod diversity.

Keywords: *Arthropod diversity, Paddy fields, Weed patches, Functional groups, Growth stages*

Acknowledgements: The authors are grateful to Dr W.M.G.A.S.T.B. Wijetunga, Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka for providing expertise in plant identification.

IMPACT OF WATER HARDNESS ON BREEDING AND FRY REARING OF *Pseudetroplus maculatus* (ORANGE CHROMIDE) (BLEEKER, 1862): A POTENTIAL SPECIES FOR SRI LANKA'S ORNAMENTAL FISH INDUSTRY

D.G.N.T.L. Jayasiri [1]*, T.V. Sundarabarathy [1] and A.R. Mudalige [2]

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
[2]National Aquaculture Development Authority (NAQDA), National Aquaculture Development Center, Dambulla, Sri Lanka.
**thakshilajayasiri1998@gmail.com*

Pseudetroplus maculatus is an euryhaline fish valued as an ornamental fish worldwide, for its bright coloration, small size and active swimming behaviour. However, its lower survival rate under captive conditions has limited its use in Sri Lanka's aquarium trade. This study was conducted to address the low survival rates by investigating the effect of water hardness on the breeding and fry rearing of *P. maculatus*. The brooders were collected from Kala Oya located in Northwestern province of Sri Lanka. The effects of water hardness on breeding and fry rearing were examined under four different hardness levels representing various regions: 35.00 ppm (Kandy), 71.20 ppm (Dambulla – Control), 90.00 ppm (Matara) and 178.00 ppm (Jaffna) each tested in triplicates. Male and female fish were separately acclimated to the experimental water hardness for two weeks. They were fed with a commercial diet with crude protein (42.0%), fat (10.0%) and minerals twice daily at a rate of 5% of body weight. Breeding experiments were conducted using twelve glass tanks (32 L capacity), each with a substrate of small rocks and sand. Individual pairs were introduced into each breeding tank in the evening, and breeding trials were carried out in two separate phases. Two fry rearing experiments were performed with and without parental care in different water hardness levels using a stocking density of 5fry/L (total 35fry/tank). Postlarvae were fed with egg yolk and *Artemia* while fry were offered *Artemia* and micro worms ad libitum. Growth performance and survival rates of the fry were monitored over a period of six weeks. No significant difference in breeding success ($P > 0.05$) was observed across the different water hardness conditions in both breeding trials. Pre- and post-spawning behaviours remained consistent under all experimental conditions. Although water hardness did not influence fertilization rates or egg hatchability, comparatively higher spawning rates were recorded at 90 ppm and 178 ppm hardness levels. In the first trial, the highest length (11.1 ± 4.45 mm), specific growth rate in length (SGR-L, 2.8%), weight gain (52.7 ± 21.13 mg), and specific growth rate in weight (SGR-W, 5.6%) were recorded at 178.00 ppm water hardness. In the second trial, the highest length (11.1 ± 3.96 mm), SGR-L (2.9%), weight gain (55.9 ± 21.53 mg), and SGR-W (5.7%) were observed at 71.20 ppm water hardness. The highest survival rate of fry was recorded at 90 ppm water hardness, with 178 ppm exhibited the second-highest survival rate. Parental care had a significant positive impact on fry survival. Additionally, *P. maculatus* fry exhibited a negative allometric growth pattern under all water hardness conditions. Water hardness levels of 90.00 ppm and 178 ppm are recommended to achieve higher breeding success and fry survival rates in *P. maculatus.*

Keywords: *Water hardness, Breeding behaviour, Length gain, Weight gain, Survival*

BIODIVERSITY AND SOCIO-ECONOMIC CONDITIONS OF TWO SELECTED FRESHWATER TANK ECOSYSTEMS IN THE DRY AND INTERMEDIATE CLIMATIC ZONES OF SRI LANKA

L.D.K. Mudalige[1] and C. Sarathchandra[1]*

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
**chayasarathchandra@gmail.com*

Freshwater tanks are manmade water bodies referred to as "Wewa (singular)/Wew (plural)", serve as vital ecosystems that support both biodiversity and rural livelihoods. This study investigated and compared the biodiversity and socioeconomic conditions of two freshwater tanks, Nuwara Wewa in the Dry Zone of Anuradhapura District and Dewahuwa Wewa in the Intermediate Zone of Matale District. Both biological and physiochemical data were collected following standard methods. Biodiversity surveys were focused on floristic and faunistic diversity, including birds, butterflies and fish, and were conducted at two study sites per tank, reflecting variations in human disturbance. The standard ecological indices, Shannon–Wiener, Simpson's, Margalef's and evenness indices, were used for diversity analysis. The socio-economic survey involved 25 households per tank using a standardized questionnaire. A total of 21 aquatic plant species (17 families) was recorded from both freshwater tanks: 1 submerged species, 11 emergent species, 6 free-floating species and 3 plants that have floating leaves and are attached to a substrate. Aquatic plant and freshwater fish diversity were greatest at sites with better water quality. The faunistic diversity of Nuwara Wewa (Dry Zone) comprised 11 fish species (6 families), including 2 exotic and 9 indigenous species; 31 butterfly species (5 families); and 58 bird species (32 families). The Nuwara Wewa avifauna included 4 endemic species, the Sri Lanka Grey Hornbill, Sri Lanka Barbet, Sri Lanka Swallow and Sri Lanka Jungle fowl. From Dewahuwa Wewa (Intermediate Zone) we recorded 9 fish species (5 families), including 3 exotic and 6 indigenous species; 19 butterfly species (4 families); and 49 bird species (27 families), including 1 endemic species, the Sri Lanka Swallow). Bird diversity was highest at Dewahuwa Wewa site 2, which had relatively low human disturbance (H' = 3.28) in the morning (6:00–8:00 hours). Bird diversity was lowest at Nuwara Wewa site 1, which had higher levels of human disturbance (H' = 2.95) in the morning (6:00–8:00 hours). The Dewahuwa Wewa communities exhibit higher dependency on fisheries and agriculture, facilitated by stable irrigation infrastructure and an organized fishing committee; 52% of households identified fisheries as their primary income source. In contrast, only 16% of participants in Nuwara Wewa relied on fishing, where fishing is poorly regulated and impacted by illegal fishing practices such as the use of small-mesh gill nets below the legally permitted mesh size. Livelihoods around Nuwara Wewa were more diversified, including agriculture, vending and tourism-related occupations due to the Wewa's proximity to Anuradhapura sacred city. With regard to household income patterns, the Dewahuwa Wewa participants reported a higher proportion (68%) of monthly income in the range of Rs 50,000–100,000. Dewahuwa Wewa site 2 faces major challenges from the invasive plant species *Salvinia molesta*, *Pontederia crassipes* and *Lemna minor*, which pose a significant threat to the aquatic ecosystem. Plastic pollution, especially from visitors discarding garbage, was identified as a pressing issue at Nuwara Wewa site 1, further intensifying environmental degradation at that site. These findings underline how strongly climatic zones, human activities and invasive species affect both the biodiversity and socioeconomic conditions of freshwater tanks and emphasize the need for both effective tank and fisheries management practices and integrated, context-specific conservation strategies.

Keywords: *Freshwater tanks, Nuwara Wewa, Dewahuwa Wewa, Dry zone, Intermediate zone, Socioeconomics, Biodiversity assessment*

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THE RELATIONSHIP BETWEEN SEXUAL MATURITY AND THROAT COLOUR INTENSITY IN THE MALE LITTER SKINK, *Lankascincus fallax*

P.A.S. Roshima[1], R.L. Jayaratne[1] and K.D.B. Ukuwela[1]*

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale 50300, Sri Lanka.
**kanishka@as.rjt.ac.lk*

Colour polymorphism is a widespread phenomenon in the animal kingdom, and elucidating the mechanisms that generate and sustain this phenotypic diversity remains a central goal in evolutionary biology. *Lankascincus fallax* is an endemic skink to Sri Lanka, which exhibits three distinct throat colour morphs (red with white spots, black with white spots, and white), where the brighter throat colours occurring exclusively in larger males. In this study, we examined the relationship between sexual maturity (i.e. testicular maturity) and throat colour intensity in male *L. fallax*. Testicular maturity was determined through histological examination of testes in preserved *L. fallax* specimens. Throat colour intensity was quantified by extracting RGB (Red, Green, Blue) values from standardized digital photographs of the throat in live skinks, using ImageJ 2.0 software. The results revealed that the snout–vent length (SVL) (39.75 mm) of individuals with mature testes were significantly larger than the SVL (28.39 mm) of individuals with immature testes indicating a strong relationship between body size and testicular maturity. Furthermore, in red and white throated individuals, there was a positive correlation of red intensity with SVL and a negative correlation with blue and green intensities, suggesting that red colouration becomes more pronounced as red throated individuals grow. In black and white throated individuals, there was a positive correlation of blue intensity with SVL and a negative correlation with red intensity, suggesting that blue colouration becomes more pronounced as black throated individuals grow. These patterns indicate that throat colour intensity increases with body size (i.e. SVL) in *L. fallax* males. Taken together, these findings suggest that the bright throat colours of male *L. fallax* may serve as a reliable indicator of sexual maturity.

Keywords: *Colour polymorphism, Sexual maturity, Throat colour intensity, Testicular histology, Snout-vent length (SVL), RGB colours*

Acknowledgements: The authors gratefully acknowledge the Department of Wildlife Conservation for granting permission (WL/3/2/70/15 and WL/3/2/44/2024) to conduct this study.

VARIATION IN SOCIAL BEHAVIOUR AND PLAY AMONG ASIAN ELEPHANT (*Elephas maximus*) CALVES IN THE MINNERIYA AND KAUDULLA NATIONAL PARKS, SRI LANKA

K.M.D. Sepalika[1]*, S. Wickramasinghe[1], R.P.G. Vandercone[2,3] and C.A. LaDue[3,4]

[1]*Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.*
[2]*Department of Zoology, Faculty of Science, University of Peradeniya, Peradeniya, Sri Lanka.*
[3]*Sri Lanka Elephant Project (SLEP).*
[4]*Oklahoma City Zoo and Botanical Garden.*
**dhananisep4@gmail.com*

Play is a widespread phenomenon observed across many animal species and is particularly important in mammalian development. In elephants, play and tactile social interactions are critical for calf development, influencing social skills, physical health and overall well-being. This study aimed to document the play repertoire and frequency of social interactions among calves in Minneriya and Kaudulla National Parks, Sri Lanka, and to explore how these behaviours varied between newborns and calves nearing 1 year of age. Data were collected from July 2024 to January 2025 using the focal animal sampling method and established ethograms. State behaviours were recorded at 1-minute intervals, and event behaviours continuously during 15-minute observation bouts. A key finding was the significant variation in social play behaviour among elephant calves based on maternal proximity, with those further (> 1m) from their mothers exhibiting higher frequencies of social play (mean = 11.07) compared to those within (< 1m) with a *P*-value of 0.004. However, there were no significant differences in locomotor play based on distance from mother ($P = 0.357$), suggesting that proximity primarily affects interactive rather than solitary behaviours. Additionally, no significant differences were observed in object play frequencies between the two proximity groups ($P = 0.217$). When comparing developmental stages, newborn and 1-year-old calves showed similar patterns in both social play ($P = 0.312$) and locomotor play ($P = 0.733$) behaviours, indicating that these specific play patterns remain relatively consistent during early development despite the notable influence of maternal proximity on social engagement. Further analysis of behavioural frequencies revealed notable age-related differences in several behaviours. Protection behaviours were significantly higher in newborn calves (mean = 12.86) compared to 1-year-olds (mean = 5.54), suggesting increased maternal vigilance during early development. Non-play tactile interactions remained relatively consistent across age groups (newborn = 9.14, 1-year old = 9.25), highlighting the continued importance of touch-based social interactions throughout early development. The findings of this study demonstrated the elaborate interaction between maternal proximity and developmental stage in shaping the social play behaviour of wild Asian elephant calves, and how the early social environment has a subtle impact on the calves' interactive play patterns and indicated that they consistently engage in specific play types throughout early development stages.

Keywords: *Play repertoire, Maternal proximity, Early development stage, Tactile interaction, Social play*

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CONSERVATION GENETICS OF THE ENDANGERED SKY ISLAND LIZARD *Ceratophora stoddartii*

W.M.N. Tharaka[1] and K.D.B. Ukuwela[1]*

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
**kanishka@as.rjt.ac.lk*

Global biodiversity is undergoing an unprecedented crisis, with accelerating species extinctions driven by habitat loss, climate change and fragmentation, necessitating immediate conservation action. Genetic diversity is crucial for species survival and adaptation, underscoring conservation genetics as an essential tool in biodiversity preservation. *Ceratophora stoddartii* (Rhino-horned lizard), an endangered arboreal agamid lizard species endemic to Sri Lanka's montane cloud forests, is found at elevations of 1000–2500 m. The species is highly vulnerable to habitat fragmentation and isolation within these 'sky island' habitats. This study presents the first population genetic investigation of a montane lizard species in Sri Lanka, aiming to evaluate the genetic structure and genetic diversity of *C. stoddartii* across its distribution range, providing insights for its conservation. Tail tissue samples of lizards were collected from selected montane forest sites across Sri Lanka, encompassing the known elevational range of the species. DNA was extracted from the collected tissue samples and mitochondrial ND2 gene was amplified and sequenced. Population genetic structure was assessed using phylogenetic analysis (Bayesian and Maximum Likelihood), haplotype network analysis (median-joining method). A Spearman's rank correlation test was performed to test whether the observed pattern of genetic divergence correlated with geographic distance. Molecular diversity indices were calculated to estimate genetic diversity among geographically distinct populations. Phylogenetic analyses identified two major clades: one representing the Raxawa Mountain population and the other comprising the Central Highlands populations indicating two distinct evolutionary lineages. Uncorrected pairwise genetic distances ranged from 0.00 to 4.89%, with the Raxawa population exhibiting the highest divergence (3.53–4.89%) from all others. The Central Highlands clade exhibited genetic variation ranging from 0.00 to 3.80%, with some populations showing genetic uniformity, while others displayed moderate differentiation. Haplotype network analysis revealed eight unique haplotypes across all populations, with no haplotypes shared among sites, further supporting strong population structuring and limited gene flow. Spearman's rank correlation test indicated a significant positive relationship between genetic distance and graphic distance. The Raxawa population exhibited the highest diversity (π = 0.00212), while some populations showed complete genetic uniformity. However, the overall nucleotide diversity across the species' range was considerably higher (π = 0.02613), indicating accumulated genetic variation across populations. These results indicate that *C. stoddartii* comprises genetically distinct, geographically structured populations, with long-term isolation contributing to divergence. The deep divergence between the Raxawa Mountain and Central Highland lineages supports their recognition as separate conservation management units. Future studies integrating whole-genome sequencing and expanded geographic sampling are essential for further refining conservation strategies and investigating the historical drivers of population subdivision.

Keywords: *Conservation genetics, Population structure, Genetic diversity, Sky islands, Habitat fragmentation*

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RELATIVE ABUNDANCE AND ACTIVITY PATTERNS OF MESO MAMMALS IN THE KALUDIYAPOKUNA FOREST RESERVE IN DAMBULLA, SRI LANKA

W.M.U.I. Weerasinghe[1]*, S. Wickramasinghe[1] and R.P.D. Vandercone[2]

[1]Department of Biological Science, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
[2]Department of Zoology, Faculty of Science, University of Peradeniya, Peradeniya, Sri Lanka.
**udaniindrachapaweerasinghe@gmail.com*

Achieving a comprehensive understanding of the ecology and behaviour of meso mammals is essential for the conservation and management of critical forest ecosystems. This study examines the relative abundance and activity patterns of meso mammals in the Kaludiyapokuna Forest Reserve, a mid-elevation dry zone forest situated in Dambulla, Sri Lanka. This forest provides critical habitat to a variety of mammalian species including medium sized carnivores, omnivores and herbivores. A camera trapping method was used to conduct this research, with traps installed across different habitat types in the reserve to maximize species detection. During the data collection period, the camera traps continuously detected and recorded mammalian activity, facilitating relative abundance estimation and diel activity pattern analysis. The study analysed the relative abundance and activity patterns of mammal species using 10 camera traps over 1,444 camera trap days. Fifteen mammal species belonging to 10 families was recorded. *Axis axis* showed the highest relative abundance index (RAI = 1.93), followed by *Muntiacus muntjak, Hystrix indica,* and *Macaca sinica sinica.* Notably, the monthly RAI showed fluctuating abundances, with *Semnopithecus priam* and *Macaca sinica sinica* exhibiting a marked decline after September. In contrast, *Axis axis* and *Sus scrofa* showed stable detection rates. These findings provide important insights into species abundance and seasonal activity patterns, informing future conservation planning. Analysis of activity patterns and temporal overlap among meso mammals revealed that *Muntiacus muntjak* was active both during the day and night, with peaks from 06:00–12:00 hours and from 18:00–24:00 hours. *Hystrix indica* was exclusively nocturnal, while *Sus scrofa* exhibited irregular activity throughout the day. *Axis axis* and *Cervus unicolor* were mainly nocturnal but showed some daytime activity, while primates, such as *Macaca sinica sinica* and *Semnopithecus priam* were primarily diurnal. Overlap analysis indicated greater temporal overlap among species with similar activity patterns. In contrast, diurnal–nocturnal comparisons showed lower overlap values, suggesting temporal niche partitioning. The relationship between species and habitat types was examined using a chi-square test of independence. Significant associations were observed for *Axis axis*, *Semnopithecus priam*, *Macaca sinica sinica*, *Muntiacus muntjak*, *Hystrix indica* and *Sus scrofa* ($P < 0.001$), with dry mixed evergreen forest (DEF) showing a higher-than-expected presence. Aquatic, rocky and shrubland habitats showed very low species presence. *Cervus unicolor* did not show significant habitat association ($P > 0.79$), suggesting a more generalist habitat use. This study provides fundamental data on the meso mammal community in the Kaludiyapokuna Forest Reserve. The findings contribute to a broader understanding of mammalian ecology in Sri Lanka and have practical implications for conservation planning and biodiversity assessments.

Keywords: *Meso mammals, Relative abundance index, Camera trapping, Activity patterns, Kaludiyapokuna Forest Reserve*

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ASSESSMENT OF ATMOSPHERIC HEAVY METAL POLLUTANTS USING SPANISH MOSS (*Tillandsia usneoides*) AS A BIOMONITORING TOOL IN KANDY, SRI LANKA

W.M.N.A. Wijekoon[1]*, R.L. Jayaratne[1] and M.M.L.I.W. Bandara[2]

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
[2]Floriculture Research and Development Unit, Department of National Botanic Gardens, Peradeniya, Sri Lanka.
**nerandikawijekoon@gmail.com*

Atmospheric concentrations of the most commonly available heavy metals, arsenic (As), cadmium (Cd), mercury (Hg) and lead (Pb), were investigated through analysis of Spanish moss (*Tillandsia usneoide*s (L.)) transplanted across Kandy District. We examined 10 locations within the area of Kandy town and 10 locations along the urban gradient from Kandy Clock Tower to Bambaralla (near the Knuckles mountain range). Spanish moss was selected for heavy metal analysis due to its ability to absorb nutrients directly from the atmosphere without coming into contact with soil, adaptability to harsh conditions and ease of transplanting in different locations. Samples were collected over a 3-month period at 4-week intervals. Collected samples were oven dried and digested with conc. HNO_3 and H_2O_2 in the microwave digestion system. Digested samples were analysed for As, Cd, Hg and Pb using Inductively coupled plasma-mass spectrometry (ICP-MS). Basic statistics (mean, median and standard deviation) for the 20 points were calculated for 3 months and showed variation in concentration. As had variable values with a peak mean in November and a trough in December, Hg showed a declining trend from November to January with reduced variability. Cd had an increasing trend with consistent data and Pb had elevated and variable levels throughout. Pearson's correlation analysis, based on normally distributed data, revealed strong relationships among metals. As and Hg showed a strong positive correlation, while Pb and Hg had a very strong negative correlation. Cd and Pb showed a moderate positive link. These patterns suggest shared or differing pollution sources. Environmental correlations showed As and Hg linked with relative humidity, while Cd and Pb correlated with wind speed. Pb also showed strong associations with precipitation and humidity. For the 10 points within Kandy city, a two-way ANOVA was done and the *P*-values indicated that concentrations did not vary significantly by site ($P = 0.384$) but varied significantly across time ($P = 0.042$); this was attributed to environmental influences. Hg concentrations were not significantly influenced by either site ($P = 0.555$) or time ($P = 0.186$), suggesting stable levels. For Cd and Pb, site did not have any significant effect ($P > 0.05$), yet time significantly affected their concentration ($P < 0.05$), perhaps as a result of differences in local emissions or ambient conditions. Boxplot analysis revealed the spatial patterns of the four heavy metals across varying distances. Arsenic showed the highest concentration within 0–5 km, declining with distance, thus indicating potential localized contamination. Cd exhibited high variability and multiple outliers, suggesting diverse contamination sources. Hg maintained relatively consistent levels, possibly due to widespread or persistent deposition. Pb displayed a sharp increase at 25 km and notable outliers at mid-range distances, indicating a possible point-source of pollution. Even though there is variation in the accumulation of heavy metal when correlating with the urban gradient, heavy metal accumulation was observed over the 3-month duration of fieldwork. This study reveals that Spanish moss is a potential biomonitoring tool for assessing the level of spatial and temporal heavy metal accumulation in the atmosphere.

Keywords: *Heavy metals, Spanish moss, Atmospheric pollution, Urban gradient, Biomonitoring*

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IMPACT OF ENVIRONMENTAL DISTURBANCE ON THE FIG-WASP POLLINATION SYSTEM OF *Ficus religiosa* IN THE PERIPHERY OF SINHARAJA RAINFOREST (MATARA AND RATHNAPURA DISTRICTS)

T.N. Hatharasinghe[1] and W.M.G.A.S.T.B. Wijetunga[1]*

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
**asanga@as.rjt.ac.lk*

Ficus religiosa, which is monoecious and characterized by male, female and gall-flowers in the same syconium, is a deciduous fig species of the plant family Moraceae. The ecological role of this species depends heavily on an obligate mutualism with species-specific pollinating fig wasps (PFWs) of the family Agaonidae. Pollinator fig wasps deposit their eggs in the syconia of *Ficus* species, ensuring their reproductive success while also completing their life cycle within the fig's reproductive structures. In *F. religios*a several other wasp species, collectively known as non-pollinating fig wasps (NPFWs; Hymenoptera: Agaonidae), also lay their eggs and develop within the ovaries of the syconia. This study investigated the impact of environmental disturbance on the fig-wasp pollination system and was conducted from September 2024 to February 2025. Study sites are located on the periphery of the Sinharaja rainforest, in the wet zone of Sri Lanka, and fall within the Matara and Ratnapura Districts. Study sites were selected with respect to disturbance level, with three categories of disturbance being studied: highly disturbed sites, moderately disturbed sites and less disturbed sites. Twelve individual trees as one tree from each site were selected from twelve sites. ArcMap 10.8 and Google Earth Pro were used to map the locations of selected *Ficus* species. Mature syconia with no cut holes made by fig wasps were collected and measured to record their size and volume. Collected syconia and fig wasps from each syconium were preserved separately. Numbers of seeds, galls, florets, pollinator wasps (PFWs) and non-pollinator wasps (NPFWs) were counted for each syconium. A stereomicroscope was used to identify, sex and count the fig wasps during the controlled rearing process. To assess the variations and relationships between fig-wasp populations, seed production and syconial features, statistical methods were employed. The calculated means of diameter, length and volume of the syconia of twelve trees were significantly different ($P < 0.05$). The highest mean syconial diameter was recorded at Aninkanda (1.476 cm), the highest mean syconial length was observed at Pallegama (1.751 cm) and the largest mean syconial volume was also found at Pallegama (2.20 cm^3) which both sites are highly disturbed. The number of seeds, galls, florets, PFWs and NPFWs were significantly different among the 12 trees ($P < 0.05$). Among the sites, Aninkanda showed the highest median seed count (152). Adaradeniya 1 recorded the highest gall (122) and the floret (304) counts. Panilkanda exhibited the highest median count of pollinating female fig wasps (PFFWs). The greatest number of pollinating male fig wasps (PMFWs) was observed at Getabaruwa, which also had the highest count of NPFFWs (10.0). Olakumbura had the highest abundance of non-pollinating male fig wasps (NPMFWs). The PFFWs, PMFWs, NPFFWs and NPMFWs and their sex ratios were significantly different ($P <0.05$) among the sites. The sex ratios of PFWs and NPFWs varied across sites, with some showing male-biased ratios and others exhibiting female-biased or more balanced ratios. The ratio of PFWs and NPFWs was significantly different among the sites ($P < 0.05$). The study reveals that environmental disturbances negatively affects syconial characters, pollinator/non-pollinator relationships and the overall fig-wasp pollination system of *F. religiosa*.

Keywords: *Fig-wasp mutualism, Ficus religiosa, Environmental disturbances, Pollination, Habitat fragmentation*

HABITAT PREFERENCE OF *Calotes ceylonensis* IN KALUDIYAPOKUNA FOREST RESERVE, DAMBULLA, SRI LANKA

P.P.G.S.W. Kumarathunga[1]*, T. Abayarathna[1] and R. Vandercone[2]

[1]*Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.*
[2]*Department of Zoology, Faculty of Science, University of Peradeniya, Peradeniya, Sri Lanka.*
**wishwapali98@gmail.com*

Understanding habitat preference is crucial in ecology to understand the distribution, population dynamics and survival of a species. This study investigates the macro- and microhabitat preferences of the endemic Sri Lankan arboreal lizard *Calotes ceylonensis* within the Kaludiyapokuna Forest Reserve, Dambulla. The study also addresses the question of whether environmental and habitat variables influence the macrohabitat and microhabitat selection and preferences of this species within the forest ecosystem. Fieldwork was conducted from August 2024 to January 2025 using visual encounter surveys across multiple 100 × 20 m sampling units representing diverse habitat types, including forest trails and off-trail areas. Each sampling unit was investigated monthly for over 10 days per month for 5 months, from 07:00 to 17:00 h. At each sighting point, perch characteristics, environmental conditions and vegetation structure were recorded including ambient temperature, relative humidity, light intensity, leaf litter depth, perching height, perch diameter and diameter at breast height (DBH) of the tree the individual was encountered on and percentage cover of canopy, vegetation, grass, bare ground, leaf litter, rock and fallen log using 1-m radius circular plots; the same measurements were collected in unoccupied plots for comparison except perch height and perch diameter and DBH. A total of 89 sightings was recorded, with a sighting frequency of 0.356 per human hour. Macrohabitat preference was assessed using the chi-square goodness-of-fit test, which revealed significant variation in lizard distribution among habitat types ($\chi^2 = 95.89$, df = 4, $P < 0.001$) with the archaeological site being the most preferred habitat. They also showed a strong microhabitat preference for tree trunks, with minimal or no use of other available substrates. Spearman correlation analysis revealed a weak negative correlation ($r = –0.277$, $P = 0.237$) between the relative abundance of tree species and lizard occupancy, suggesting selective use of specific tree species regardless of availability. Preferred species included *Cryptocarya* sp. and *Polyalthia coffeoides*. *Calotes ceylonensis* were observed on trees with a mean DBH of 41.04 ± 25.12 cm. The perching height of *C. ceylonensis* varied widely, ranging from a minimum of 0.3 m to over 10 m. Principal Component Analysis (PCA) identified canopy cover, humidity, leaf litter depth and bare ground as key variables structuring microhabitat use. The Mann–Whitney *U*-test showed significant differences in several microhabitat variables between occupied and unoccupied plots. Occupied sites had significantly lower relative humidity, rock cover, bare ground and fallen log cover, while ambient temperature, leaf litter cover and tree DBH were significantly higher ($P < 0.05$). No significant differences were observed in grass cover, leaf litter depth or vegetation cover. Behavioural data indicated that lizard sightings peaked during the morning (07:00–12:00 hours), with basking and resting being the most common activities. The study revealed that *C. ceylonensis* select their preferred habitat over other available habitats at Kaludiyapokuna Forest Reserve. This finding forms a base for interpreting distribution, population dynamics and survival of this lizard.

Keywords: *Habitat preference, Microhabitat variables, Calotes ceylonensis, Dry zone forest*

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MELISSOPALYNOLOGY STUDY IN THE GALLE DISTRICT, SRI LANKA

R.R. Vithanage[1]*, D.K. Hettiarachchi[1] and D.P. Samarasinghe[2]

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
[2]Postgraduate Institute of Archeology. Univrsity of Kelaniya, Kelaniya, Sri Lanka.
**vithanageravindi@gmail.com*

Bees are considered vulnerable due to a number of reasons. One of these has been loss of habitat and favourable food plants species. Bees mainly collect nectar and, as a secondary activity collect pollen, the main source of protein for bees. After collecting pollen, it is mixed with saliva and nectar and stored in bee cells. This is called bee bread and is caramel-coloured when fermented. This bee bread can be used to study bee-collected pollen. Melissopalynology, which is the study of pollen present in honey and bee bread, is important to determine the floral sources, geographical origin, family, and genus of the plants that bees visit. The present study aimed to identify the major plant sources that form bee foraging resources. Understanding the floral composition of bee bread provides insights into plant–pollinator interactions and helps conserve pollinator habitats. This study was conducted in 20 man-made bee hives in the Galle District. Bee bread samples were selected from October to December 2024. Erdtman's acetolysis technique was used to analyze the pollen in collected bee bread. The morphology of pollen was observed with a light microscope to identify pollen families. Further pollen count was taken from prepared slides to apply the Shannon and Simpson diversity indices. Pollen belonging to 34 plant families were identified from the 20-bee hives. The families were: Acanthaceae, Amaranthaceae, Amalidaceae, Apocynanceae, Araceae, Arecaceae, Asteraceae, Balsaminaceae, Bignoniaceae, Brassicaceae, Calophyllaceae, Clusiaceae, Commelinaceae, Convolvulaceae, Cucurbitaceae, Cyperaceae, Diliniaceae, Dipterocarpaceae, Eleocarpaceae, Erioculaceae, Euphorbiaceae, Fabaceae, Fabaceae/tetrad, Fabaceae/polyad, Lamiaceae, Loranthaceae, Malastomataceae, Malvaceae, Myrtaceae, Poaceae, Rhizophoraceae, Rosaceae, Rubiaceae, Rutaceae, Sapotaceae and Theaceae. Among them, Araceae, Euphorbiaceae, Eleocarpaceae, Fabaceae, Fabaceae/tetrad, Myrtaceae, Asteraceae, Cucurbitaceae, and Diliniaceae were the most abundant plant families present in bee bread collected from all sites. Site 10 showed the highest pollen diversity (2.4945) and few families: Euphorbiaceae, Eleocarpaceae, and Fabaceae tetrad, dominate (0.8982). The diversity of plants has allowed bees better pollen choices. These findings underscore the importance of pollen analysis in understanding bee foraging patterns and identifying key floral resources. Through identifying the major plant sources for honeybees, this study also demonstrates the potential for expanding sustainable apiculture in Sri Lanka.

Keywords: *Bees, Bee bread, Foraging patterns, Pollen analysis, Plant families*

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AVIFAUNAL DIVERSITY AND ABUNDANCE IN RELATION TO ELEVATION AND LAND USE OF RAWAN OYA, KANDY SRI LANKA

B.T.S.T. Fernando[1]* and R.L. Jayaratne[1]

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
**saumyafdo99@gmail.com*

Riparian ecosystems are a complex entity of the landscape and display structures and processes that reflect the impact of a diverse range of ecological variation. These ecosystems provide resources (i.e., food and habitat) that sustain a large avifaunal community. Although globally several studies have been conducted to assess avifaunal diversity in relation to elevation gradients and land use, a limited number of such studies have been conducted in Sri Lanka. Therefore, a comprehensive study to understand avifaunal diversity and abundance in relation to elevation gradients and land use patterns was carried out in the riparian zone of the Rawan Oya, a perennial stream located on a tributary of the Mahaweli River, Kandy, Sri Lanka. The study was conducted over an 8-month period from June 2024 to January 2025 across three study sites, Angammana, Rahas Ella and Polgolla, where we sampled diverse land use patterns, including natural forest patches, home gardens, paddy fields and near Polgolla dam area. Direct observations were made using line transect and point count methods. The study revealed a total of 2,530 individual birds belonging to 112 species in 51 families, including 85 resident species (76%), 9 migrant species (8%) and 18 endemic species (16%). Furthermore, this total included 2 vulnerable species (2%), 8 near threatened species (7%) and 102 species of least concern (91%). Our results showed that 32 species were common across the three study sites while 24 bird species were specific to Angammana, 10 species to Rahas Ella and 14 species to Polgolla. The Bray–Curtis similarity reveals Angammana–Polgolla has a higher similarity (0.6310) than Angammana–Rahas Ella (0.4314), indicating that elevation had no effect on avifaunal composition. A chi-square test of independence revealed that the distribution of feeding guilds varied across the study sites and that feeding guilds are strongly dependant on the different land use types within each study site, hence land use pattern shapes the habitats where the feeding guilds have obtained their resources. Additionally, a mixed-species flocking phenomenon was observed in the Rawan Oya riparian zone. In sum, our results show that land use patterns rather than elevation shapes the avifaunal diversity and abundance in the Rawan Oya riparian zone. We identified loss of vegetation, forest fires, habitat fragmentation, firewood and timber collection, forest edge roadsides, waste dumping and illegal encroachment of forests were identified as threats. We suggest that measures for the conservation of the avifauna of Rawan Oya riparian zone should include proper law enforcement, awareness sessions, regulation of noise levels and speed levels of vehicles on forest edge roads and control of improper waste disposal practices.

Keywords: *Avifauna, Rawan Oya, Elevation gradient, Land use pattern, Riparian zone*

INFLUENCE OF DISTURBANCE REGIMES ON FIG-WASP RELATIONSHIPS AND SYCONIAL CHARACTERISTICS OF *Ficus tinctoria* (MORACEAE) IN SOME SELECTED SITES OF KANDY AND MATALE DISTRICTS

W.M.A.U. Wijesinghe[1]* and W.M.G.A.S.T.B. Wijetunga[1]

[1]*Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.*
*amanthiwijesinghe@gmail.com

The fig–fig wasp interaction is an obligate mutualistic relationship. *Ficus tinctoria* (Moraceae) is a dioecious hemi-epiphytic fig tree species. Its pollinator wasp is *Liporrhopalum rutherfordi indicum* (Hymenoptera: Agaonidae). The present study investigated the influence of vegetation disturbance regimes on the fig–fig wasp relationship and syconial characteristics of *F. tinctoria* across two study sites and was conducted from October 2024 to February 2025. After several pre-visits to the sites, study sites were selected based on the difference of disturbance level in their vegetation. The study sites were the less disturbed Nattarampotha area, which belongs to the Kundasale Divisional Secretariat, Kandy District (Site 1), and the more disturbed urban core within Matale Municipal Council Area (Site 2). Mature syconia were collected, their diameter measured, cut into two halves and reared in the laboratory until the complete wasp emergence. The number of galls and florets per syconia, number of pollinator fig wasps (PFWs) and non-pollinator fig wasps (NPFWs) were counted and recorded according to their sex. Percentage contribution of galls in the syconium for fig wasp production was higher in the syconia from Site 1 (89.00%) than Site 2 (79.85%). Syconial diameter (DS), syconial volume (VS) and number of florets per syconium (Fl/S) were comparatively higher at Site 2 and accordingly mean values of all of these characters were recorded highest in Site 2 (DS = 9.46 ± 1.45 mm; VS = 473.23 ± 229.57 mm^3; Fl/S = 134.60 ± 21.6). But there was a significant difference (P = 0.035) between the two study sites in the number of florets per syconium. The sex ratio of PFWs in Site 1 was 0.06 and in Site 2 was 0.30, indicating that Site 1 is more female-biased than Site 2. The pollinator ratio of Site 1 (0.40) was significantly higher ($P = 2.14 \times 10^{-8}$) than that of Site 2 (0.10). At site 1, there was a strong positive correlation between total non-pollinator fig wasps (TNPFWs) and pollinator male fig wasps (PMFWs) (r = 0.785) and between non-pollinator male fig wasps (NPMFWs) and PMFWs (r = 0.824), whereas there was no strong correlation between any types of fig wasps in Site 2. These findings suggest that disturbance levels significantly affected pollination success and wasp oviposition. Site 1 showed higher rates of successful pollination and greater wasp abundance within syconia, indicating a stable and well-balanced mutualistic relationship. There were female-biased wasp populations observed at both sites, but the bias was stronger at Site 1. The higher proportion of female wasps at Site 1 contributed to the overall stability of the fig-wasp mutualistic relationship. This study reveals the significant effects of disturbance on the relationship between *F. tinctoria* and its associated fig wasp species. The findings support the conclusion that increased disturbance negatively impacts syconial characteristics and fig–fig wasp relationships.

Keywords: *Liporrhopalum rutherfordi, Galls, pollinators, Non-pollinator*

RELATIVE ABUNDANCE AND DIVERSITY OF AVIFAUNA AND MAMMALS ALONG THE LAND USE GRADIENT OF THE ENDANE BIODIVERSITY CORRIDOR LANDSCAPE, NIVITHIGALA, SRI LANKA

K.A.I.A. Kodithuwakku[1]*, S. Wickramasinghe[1] and N. Geekiyanage [2,3]

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
[2]Department of Plant Science, Faculty of Agriculture, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
[3]Endane Field Research Station, Dilmah Conservation, Dilmah Ceylon Tea (Pvt) Ltd, Nivithigala, Sri Lanka.
**isuruanuradhakodi@gmail.com*

The Endane Biodiversity Corridor (EBC) is an ecological corridor in Sri Lanka that connects the Iharakanda proposed forest reserve with the Walankanda forest reserve (WFR), part of the Sinharaja Forest Reserve. This study investigated the species richness, abundance and diversity of avifaunal and mammalian communities across four land use types associated with the EBC: restored area (RA; i.e. abandoned tea), home gardens (HG), productive tea lands (PT) and a forested part of the WFR that borders the corridor. Field surveys were carried out from July 2024 to February 2025, using a total of 21 100-m-long line transects, along with live trapping, camera trapping and both direct and indirect sampling conducted during peak avifaunal activity hours. Biodiversity patterns were evaluated using the Shannon–Wiener and Simpson's diversity indices, Margalef's richness index and Pielou's evenness index. Community composition across the land use types was compared using Bray–Curtis dissimilarity. Linear mixed-effects models were used for statistical analysis. A total of 111 avifaunal species from 48 families were recorded, including 101 breeding residents, of which 21 were endemic and 10 migratory. Additionally, a total of 14 mammal species in 9 families was recorded, including 3 endemic species. *Loriculus beryllinus* was the most abundant avian species while *Funambulus palmarum* was the most abundant mammal. The RA recorded the highest avian richness (100 species), followed by HG (79), WFR (71) and PT (69). Similarly, for mammals, the RA recorded the highest species richness (13 species), while WFR had the lowest (6 species). Forty avian species and 3 mammalian species were common to all four land use types. There were no significant differences observed in the Simpson's diversity or Pielou's evenness for avifauna. However, for the Shannon–Wiener diversity, WFR had significantly lower diversity than PT (P = 0.0425). For Margalef's richness, WFR showed significantly lower richness compared to HG (P = 0.0344) and PT (P = 0.0101), while no significant differences were found among the other land use types. For mammals, no significant differences were detected for any of the diversity or richness indices. The Bray–Curtis distance showed patterns of similarity among land use types. For birds, HG and PT were the most similar (distance = 0.3041) while RA and WFR were the most different (distance = 0.8301). HG and RA were the most similar in mammalian species composition (distance = 0.7484), while PT and WFR were the most different (distance = 1.000). This study highlighted the ecological value of biodiversity corridors and habitat restoration projects in maintaining high species richness and diversity, particularly within the EBC, which supports a wide variety of avifaunal and mammalian species.

Keywords: *Landscape connectivity, Corridor, Species diversity, Restoration, Community composition*

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MICROBIOLOGY

INFRASPECIFIC DIVERSITY OF PATHOGENIC *Bipolaris oryzae* ASSOCIATED WITH *Oryza sativa* L. IN SRI LANKA BASED ON MORPHOLOGICAL AND MOLECULAR DATA

G.W.D. Daksha[1], H.S. Ferdinandez[1]* and D.S. Manamgoda[2]

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
[2]Department of Botany, Faculty of Applied Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka.
**himashi@as.rjt.ac.lk*

Brown spot disease, a major rice plant disease caused by the fungus *Bipolaris oryzae*, poses a significant threat to rice cultivation worldwide due to its detrimental impact on crop yields and global food security. Although rice is the staple food in Sri Lanka, brown spot disease and its causative agent remain among the least studied aspects of rice pathology in the country. This presents an immediate research need to minimise its devastating impacts and for proper disease management implications. This study was conducted to understand the morphological and molecular diversity of *B. oryzae*. Paddy leaves with brown spots were collected from different geographical locations in Sri Lanka during the Maha season in 2024/2025. Eight (08) fresh isolates were obtained from field excursions, and three (03) isolates were from the University of Sri Jayewardenepura Culture Collection (USJCC). Isolates were characterised based on colony characters on three (03) different media. Based on colony morphology on potato dextrose agar (PDA), isolates were grouped into six (06) as grey with fluffy growth, grey with suppressed growth, grey and white mix with cottony growth, grey and white mix with suppressed growth, white with fluffy growth, and white with cottony growth. Sanger sequencing of internal transcribed spacers 1 and 2 with 5.8S (ITS) region, and glyceraldehyde-3-phosphate dehydrogenase (GAPDH) region was carried out following successful DNA extraction, polymerase chain reaction (PCR) and gel electrophoresis, and sequence reads were incorporated in multi-locus phylogenetic analyses. The resulted phylogram revealed that all the isolates were closely related to the neotype of *B. oryzae*. Further molecular variability analyses were performed with simple sequence repeats (SSR) and inter-simple sequence repeats (ISSR). All four (04) ISSR primers used, produced clear, reproducible polymorphic banding patterns showing genetic variability of the isolates in the generated dendrogram. However, all SSR primers produced monomorphic bands except the primer BOSSR 223. Hence, it can be concluded that ISSR markers are more sensitive and reliable in characterising genetic variability in Sri Lankan isolates of *B. oryzae*. The findings of this study are expected to enhance the understanding of the morphological and genetic diversity of *B. oryzae* across Sri Lanka. Additionally, the results may inform the development of more effective disease management strategies and support the creation of novel resistant rice varieties through marker-assisted breeding.

Keywords: *Dendrogram, Graminicolous fungi, ITS, GAPDH, ISSR, SSR*

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ANTIMICROBIAL PROPERTIES AND BIOCHEMICAL COMPOSITION OF THE MUCUS OF THE SRI LANKAN ENDEMIC SNAIL *Acavus haemastoma*

L.A.N. Deshan[1], L. Weerasekara[2], K. Wijesooriya[2], H.W.V. Pushpamal[3], E.Y. Fernando[1], D.C. Raheem[1], R. Ratnayake[4] and K.D.B. Ukuwela[1]*

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
[2]Department of Zoology, Faculty of Science, University of Peradeniya, Peradeniya, Sri Lanka.
[3]Forest Department, Galle.
[4]National Institute of Fundamental Studies, Hantana Road, Kandy, Sri Lanka.
**kanishkauku@gmail.com*

Developing novel antimicrobial treatments is crucial to combatting the growing threat of antibiotic resistance. The mucus of the Sri Lankan endemic land snail *Acavus haemastoma*, which is used in traditional medicine, may be a promising source of new antimicrobial agents. In this study, we investigated the antimicrobial properties of the mucus of *A. haemastoma*, compared the antimicrobial activity of mucus of snails from two distinct habitats and analysed the biochemical properties of the mucus. Mucus samples were collected from snails in two different habitats in Kottawa, Sri Lanka, an area of natural lowland rainforest, the Kombala-Kottawa Forest Reserve (KKFR), and an adjacent home garden. Using a modified broth dilution method, the antimicrobial activity of the mucus was tested against three bacteria, Methicillin-resistant *Staphylococcus aureus* (MRSA), *Escherichia coli* and *Pseudomonas aeruginosa*, and the fungus *Candida albicans*. Percentage inhibitions were calculated and between two to four mucus samples were randomly chosen from each group of samples (i.e. natural forest and home garden) for the biochemical analyses. These involved the determination of total carbohydrate content, total protein content, total phenol content and total antioxidant capacity, as well as the analysis of elemental composition and protein profiling. Our results show that there was a significant difference in the growth of *C. albicans* between the mucus-treated and control (distilled-water treated) samples (Wilcoxon signed-rank test: $W = 9$, $P = 0.0081$), indicating the presence of antifungal activity in the mucus. However, no significant differences were observed in the percentage inhibitions of microbial activity in snail mucus from the two habitats, indicating that habitat had no effect on antimicrobial activity. The biochemical analyses revealed that the snail mucus from forest had a higher carbohydrate content (705.5 ppm) than that from the home garden (224.1 ppm). However, there was very little variation in the phenol concentration and antioxidant capacity of mucus from the two habitats. Our results indicate a higher concentration of proteins than other biochemical components, suggesting that proteins (peptides) ranging in size from 9.44 kDa to 270.77 kDa might be a source of antifungal activity in the mucus of *A. haemastoma*. We detected high Potassium and Sodium concentrations (in ppm) and low levels of Lead, Cadmium and Arsenic, pointing to possible exposure to pollutants. These findings suggest that the mucus of *A. haemastoma* may be a promising source of animal-derived antimicrobial agents with potential applications in therapeutics, cosmetics and biotechnology.

Keywords: *Snail mucus, Antibiotic resistance, Antioxidant capacity, Elemental composition, Protein profile*

MORPHOLOGICAL AND MOLECULAR CHARACTERISATION OF GRAMINICOLOUS HYPHOMYCETOUS FUNGI ASSOCIATED WITH WILD *Oryza* spp. IN SRI LANKA

D.M.S.A. Disanayaka[1], H.S. Ferdinandez[1]* and D.S. Manamgoda[2]

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
[2]Department of Botany, Faculty of Applied Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka.
**himashi@as.rjt.ac.lk*

Sri Lanka possesses a rich fungal diversity, yet only a small fraction of it has been identified and documented to date. Graminicolous hyphomycetous fungi include six (06) genera, *Bipolaris*, *Curvularia*, *Exserohilum*, *Johnalcornia*, *Porocercospora* and *Pyrenophora*. They are typically associated with poaceous hosts including commercially important cereal crops such as *Oryza sativa* (cultivated rice), an *Oryza* species extensively grown in Sri Lanka. Wild *Oryza* spp. are considered genetically resilient than *Oryza sativa*. Sri Lanka serves as one of the secondary centres of diversity for rice genetic resources. Five (05) species of wild *Oryza*, namely *O. rufipogan*, *O. nivara*, *O. rhizomatis*, *O. granulata* and *O. eichingeri*, have been recorded in Sri Lanka each possessing potential value for rice breeding and genetic improvement. *Oryza rufipogan* is considered as the closest relative of *Oryza sativa*. To date, no comprehensive studies have been conducted on the fungi associated with wild *Oryza* species in Sri Lanka. As evidenced by existing literature, fungi associated with wild *Oryza* species may represent potential pathogenic threats to *Oryza sativa* in the future. This study was conducted with the objective of isolating and identifying saprobic and potential pathogenic fungi on wild *Oryza* spp. to conserve wild *Oryza* spp. in Sri Lanka. During the study, 21 geographical locations which confirmed the presence of wild *Oryza* spp. from a previous study were explored and 52 samples showing brown spots, leaf blight, diseased panicles and dead plant materials were collected. In total, 17 isolates obtained were initially identified based on morphological and microscopic characters. However, since the morphological characterisation alone is insufficient for accurate species identification due to the overlapping microscopic and colony characters, molecular analyses were followed. The internal transcribed spacer 1 and 2 with 5.8S region (ITS) and glyceraldehyde-3-phosphate dehydrogenase (GAPDH) loci were sequenced and used in multi-locus phylogenetic analyses following the DNA extractions, polymerase chain reaction (PCR) and gel electrophoresis. The resulted phylograms revealed that one *Curvularia* and two *Bipolaris* species form unique clades which can be described as novel species after further studies. In addition, *Curvularia geniculata*, *Curvularia saccharicola* and *Curvularia chiangmaiensis* from *O. rufipogan* were identified as novel records from Sri Lanka. This study emphasises the existence of a diverse array of fungi species among fresh collections. Therefore, it is essential to collect more samples from both crops and their wild relatives to assess the impact of these pathogens on cultivated plants, as well as to better understand their host range and evolving life mode patterns.

Keywords: *Bipolaris, Curvularia, GAPDH, ITS, Multi-locus phylogeny*

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IDENTIFICATION AND CHARACTERISATION OF ORCHID MYCORRHIZAL FUNGI (OMF) IN EXOTIC ORCHIDS CULTIVATED IN HOME GARDENS IN SRI LANKA

W.A.T.S. Jayasekara[1], K.W.Y.R. Kalamulla[1] and P.N. Yapa[1]*

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
**neelamanie@as.rjt.ac.lk*

Exotic orchids, prized for their remarkable beauty and high commercial value in local and global horticulture. Orchid mycorrhizal associations are crucial for nutrient acquisition in orchid seed germination, stress tolerance and the survival of the mature orchid plants. Most of the previous studies have focused on orchid mycorrhizal associations during early developmental stages of the native and endemic orchid plants, especially the seedling and the protocorm. However, it is underexplored the presence and the diversity of orchid mycorrhizal fungi (OMF) in the aerial roots of mature exotic orchid species in home gardens across three main climatic zones: wet, intermediate, and dry. This is the first recorded attempt in Sri Lanka to investigate the diversity, distribution, and quantitative analysis of OMF in aerial roots of the three most common exotic orchid species, namely *Dendrobium bigibbum, Oncidium sphacelatum* and *Arachnis flos-aeris* (L.) Rchb.f. found in Sri Lankan home gardens. The presence, and the peloton colonisation indices, mainly the colonisation rate (CR) revealed significant variation among orchid species and climatic zones, indicating the influence of climatic conditions on orchid mycorrhizal colonisation, while distinct species-specific morphologies of pelotons remain notably consistent across all climatic zones. Without considering the orchid species, the highest peloton colonisation rate of 58.66% was observed in the wet zone while the lowest peloton colonisation rate was observed in the intermediate zone: 38.28%. In the diversity and distribution analysis of OMF, a total of 228 root segments were cultured, yielding 107 fungal colonies, from which 10 suspected isolates were selected based on key hyphal characteristics of OMF. Polymerase chain reaction (PCR) was carried out to amplify internal transcribed spacer (ITS) region using ITS1 and ITS4 primers following DNA extraction. Similarity search using the basic local alignment search tool (BLAST) after Sanger sequencing, identified all isolates as Ascomycete fungi namely, *Epicoccum sorghinum* (100%), *Phomopsis* sp. (100%), *Diaporthe phaseolorum* (99.82%), *Diaporthe perseae* (99.64%), *Diaporthe* sp. (99.45%), *Colletotrichum siamense* (100%), *Colletotrichum truncatum* (99.62%), *Colletotrichum* sp. (99.64%) and *Curvularia geniculata* (99.46%). Although commonly reported as pathogens in many other plant species, these fungi may play a beneficial role as endophytes within orchid roots, enhancing survival and stress tolerance in mature plants by promoting plant growth. *Fusarium* sp. now recognised as an OMF from several root cultures was isolated and identified through morphological features. The presence of pelotons and the colonisation rates serve as strong indicators of OMF in aerial roots, paving the pathway for the identification of OMF through next-generation sequencing (NGS). All these findings demonstrate the contribution of OMF and their mutualistic endophytic fungi for the survival of orchids grown in home garden systems, while opening the pathway for further exploration into eco-friendly orchid propagation methods.

Keywords: *Orchid mycorrhizal fungi, Exotic orchids, Pelotons, Colonisation rate, Climatic zone*

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THE USE OF TRIGLYCERIDE PRODUCING MARINE PHOTOSYNTHETIC MICROORGANISMS FOR LABORATORY SCALE BIODIESEL PRODUCTION

R.M.S.L.B. Rathnayaka[1], B.R.C.M. Basnayaka[1], B.M.C. Somasiri[1], C.M. Jayathilake[1] and E.Y. Fernando[1]*

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
**eustace6192@as.rjt.ac.lk*

Conventional petroleum fuels are primarily used in purposes such as transportation, agriculture and industrial sectors due to their high energy density, efficiency and power. Despite of benefits, it is also causing a variety of environmental-related problems. Also, according to most scientific predictions, fossil fuel reservoirs will be diminished in the near future. Hence, the requirement of finding a new alternative to conventional petroleum fuels with the same properties has arisen and biodiesel is one of the best alternative due to its similar viscosity, energy density and renewable nature. Biodiesel is a bio-based fuel, produced from organic oils/ fats through transesterification. These biodiesels can be either directly used in engines or used after mixing with conventional petroleum fuels. Biodiesels produced from marine photosynthetic cyanobacteria belong to the third-generation of biofuels. Marine photosynthetic cyanobacteria do not require freshwater for growth and the ability of seawater to act as a nutrient source is also beneficial at industrial scale. For this research, marine cyanobacteria were collected from the coastal area of Trincomalee, Sri Lanka. Natural sea water-based media was used with sunlight to culture, select and preserve suitable cyanobacteria strains for producing biodiesel in this study. It was observed that they were able to reach to their stationary phase around 8-10 days under natural conditions with an average 12.23% (W/W) lipid yield from their dry biomass. Morphological and 16S rRNA based molecular identification confirmed a strong enrichment of *Cyanobacterium aponinum* in the cyanobacterial growth medium. According to the UV-Vis spectrometric data of chlorophyll extracts from cyanobacteria, divinyl chlorophyll-a was identified as their main chlorophyll pigment. The fatty acid composition of their lipids was analysed with GC-MS and revealed that, palmitic acid (around 75%) is the predominant component. The theoretical cetane number of the biodiesel derived from the extracted lipids was calculated as 66.4153, which exceeds the minimum cetane numbers of the ASTM D6751 and EN 14214 standards. The biodiesel produced by marine cyanobacteria in this lab-scale study demonstrated that high-quality and sustainable diesel fuel can be produced and scaled-up, if necessary, by using marine photosynthetic organisms found in Sri Lankan ecosystems.

Keywords: *Biodiesel, Petroleum fuels, Fatty acid, Cetane number*

ASSESSING THE POTENTIAL OF BIOCHAR TO INFLUENCE ARBUSCULAR MYCORRHIZAL FUNGI COLONISATION AND SOIL CARBON SEQUESTRATION IN MAIZE (*Zea mays* L.) ROOTS

L.A.C.P. Yasarathne[1], K.W.Y.R. Kalamulla[1] and P. N. Yapa[1]*

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
**neelamanie@as.rjt.ac.lk*

The 21st century's focus has been mainly on the mitigation of global environmental challenges resulting from the increase in greenhouse gas emissions. One plausible method for climate change mitigation is sequestrating atmospheric carbon dioxide (CO_2) in soil. While biochar application has shown successful results in soil carbon sequestration, the role of fungi in soil carbon dynamics and sequestration is still being explored. Arbuscular mycorrhizal fungi (AMF) are key microorganisms in the soil-plant system, playing a vital role in nutrient exchange and soil health. However, the synergistic effects of AMF and biochar on carbon sequestration remain inadequately understood. Therefore, the present study aimed to assess the effects of AMF and hardwood biochar on soil carbon sequestration using maize (*Zea mays* L.) as the host plant. A pot experiment was conducted in the plant house at Rajarata University of Sri Lanka, with five treatments arranged in a Completely Randomized Design (CRD): Control (T1), AMF (T2), biochar (T3), AMF + biochar (T4), and AMF + biochar + compost (T5). Soil organic carbon (SOC) and total carbon (TC) were quantified using the Walkley-Black method and a CHN analyser, respectively. Arbuscular mycorrhizal fungi colonisation (%) was assessed through the grid-line intersect method. Easily extractable glomalin (EEG) was solubilised in a 20 mM citrate solution and quantified using the Bradford assay. The effects of each treatment on plant growth rate were also evaluated. Biochar application significantly reduced AMF colonisation, with the T4 treatment resulting in complete suppression of root colonisation. However, compost amendment in the T5 treatment partially alleviated this suppression, yielding a colonisation rate of 22.93%, compared to 71.37% in the AMF-only treatment (T2) ($p < 0.05$). SOC sequestration varied significantly among treatments ($p = 0.00197$), with the highest accumulation observed in T2 (14.24 ± 4.44 g/kg). Interestingly, all treatments exhibited a net loss in TC over the 4-week incubation period, with values ranging from -1.50 g/kg (T1) to -4.06 g/kg (T5), suggesting that short-term carbon mineralisation processes may outweigh carbon storage mechanisms. Glomalin-related soil proteins (GRSPs), varied across AMF treatments, with T2 and T5 yielding 0.0521 µg/10 µL and 0.3835 µg/10 µL, respectively. While plant biomass remained statistically not significant, chlorophyll content significantly increased in T4 (24.73 ± 2.56) and T5 (25.47 ± 1.70) relative to the control, indicating improved nutrient acquisition by AMF symbiosis, despite reduced colonisation. These findings underscore the complexity of biochar–AMF interactions in regulating soil carbon dynamics. Suppressive effects of biochar on fungal colonisation, offset by compost co-application, highlight the need for promising strategies to enhance microbial activity and soil carbon retention by maize roots.

Keywords: *Arbuscular mycorrhizal fungi, Biochar, Carbon sequestration, Climate change mitigation, GRSPs*

Acknowledgements: The authors are grateful to all individuals and organisations for their support and contributions to this research.

IN-VITRO DEVELOPMENT AND CHARACTERISATION OF BIOFILMS USING MARINE MICROORGANISMS ISOLATED FROM BIOFOULING SITES

K.D. Herath[1,2], R. Pathirana[1], P.N. Yapa[2], G. Seneviratne[1] and M. Premarathna[1]*

[1]Microbial Biotechnology Unit, National Institute of Fundamental Studies, Kandy, Sri Lanka.
[2]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
**mahesh.pr@nifs.ac.lk*

Diverse marine microorganisms colonise both abiotic and biotic submerged surfaces to form biofilms. When biofilms develop on the submerged parts of ships, they form biofouling, which poses a significant challenge to the maritime industry. In the present study, biofilms were developed using marine microorganisms isolated from biofouling sites, to identify natural methods to disrupt these biofilms and characterise the biochemical composition of their extracellular polymeric substances (EPS) for potential ecological, industrial, and medicinal applications. Samples were collected from ship hulls affected by biofouling at the Mirissa Fisheries Harbour in Weligama, Sri Lanka. Six (06) marine bacteria were isolated using ZoBell marine agar (ZMA) under standardised conditions, designated as A, B, C, D, E, and F, and were further characterised by biochemical tests. The genomic DNA was extracted from marine bacterial samples using the Presto™ Mini gDNA bacteria kit (GBB100) for their molecular identification. Fungal-bacterial biofilms (FBBs) were developed by co-culturing each bacterium with *Aspergillus niger* in ZoBell marine broth (ZMB) and Yeast mannitol broth (YMB). Four (04) treatments were applied using the Crystal violet assay in a 96-well microtiter plate as follows: Treatment 1 and Treatment 2 involved simultaneous addition of marine bacteria and *A. niger* to YMB, and ZMB, respectively. Treatment 3 and Treatment 4: *A. niger* was introduced first, followed by marine bacteria after 24 hours to YMB, and ZMB, respectively. Each bacterium and *A. niger* were tested in triplicate to ensure the reliability of the data. Qualitative evaluations of biofilms were conducted using microscopy and the Congo red assay. The EPS of each FBB combination were extracted using a physicochemical method that involves heating, ultrasonication, and centrifugation. The four (04) treatments showed significant differences in microbial biomass based on a one-way ANOVA analysis (p = 0.008), with Treatment 1 displaying the highest optical density value. In Treatment 1, bacterium E exhibited the highest optical density value of 3.40, while the other isolates, A, B, C, D, and F exhibited optical density values of 3.06, 2.81, 2.57, 2.87, and 2.34, respectively (P = 0.582). Post-hoc Turkey's HSD test results revealed that the microbial biomass of Treatment 1 and Treatment 3 was significantly different (p = 0.009). This study demonstrated that the studied marine bacteria are capable of forming FBBs associated with *A. niger* under laboratory conditions. The identification of the individual microorganisms and the characterisation of their biofilm-EPS biochemicals are still ongoing processes.

Keywords: *Biofouling, EPS, Fungal-bacterial associations, Marine biofilms*

IDENTIFICATION AND CHARACTERISATION OF THE FUNGAL PARASITE *Enterocytozoon hepatopenaei* (EHP) AND EHP ASSOCIATED *Vibrio* spp. IN CULTURED PENAEID SHRIMPS IN SRI LANKA

L.T.D. Lokuvithana[1], P.P.M. Heenatigala[2]*, S.B.K. Dunisinghe[2], A.H.T. Perera[2] and P. N. Yapa[1]

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
[2]Inland Aquatic Resources and Aquaculture Division, National Aquatic Resources Research and Development Agency (NARA), Colombo 15, Sri Lanka.
**Prajani15@hotmail.com*

Hepatopancreatic microsporidiosis (HPM) is a newly emerging disease caused by the microsporidian parasite *Enterocytozoon hepatopenaei* (EHP). It has critically affected the two most common penaeid shrimp species cultivated in Sri Lanka, namely, *Penaeus vannamei* (white leg shrimp) and *Penaeus monodon* (giant tiger prawn). This study investigated the EHP strain variation in Sri Lanka and their interactions with *Vibrio* species, along with the influence of environmental factors on EHP prevalence and the antibiotic sensitivity of EHP-associated *Vibrio* spp. EHP-positive penaeid shrimp hepatopancreas samples were subjected to the nested PCR targeting the spore wall protein (SWP) gene of the pathogen to determine the strain variation and their genetic lineage. Sequences obtained were subjected to the homology search using the Basic Local Alignment Search Tool to identify the EHP strains. The results revealed that the isolates belong to 4 different EHP strains, among them three strains were closely related to the EHP strains from Thailand (KX258197.1) and India (KY483639.1) with a high bootstrap value of 94, while other strain clustered with isolates from Malaysia (MW000459.1 and MW000460.1) and India (OR544029, OR236697, and OP829216.1). This variation may be due to different sources of broodstock importation or independent evolutionary paths. Upon identification of *Vibrio* species associated with EHP, five different species of *Vibrio* were identified, namely *Vibrio parahaemolyticus, Vibrio fluvialis, Vibrio alginolyticus, Vibrio vulnificus* and *Vibrio harveyi*. A correlation analysis suggested a potential link between EHP presence and increased *Vibrio* colonisation, indicating that EHP infected shrimp may be more susceptible to *Vibrio* infections. Additionally, this study compared the effect of variations in selected physicochemical parameters [pH, DO (dissolved oxygen), temperature and salinity] between EHP-positive and EHP-negative pond water samples to assess their influence on the presence of EHP. The results indicated that EHP-positive ponds exhibited more stable and higher pH levels, lower DO levels (<6 mg/L), higher temperatures, and a broader salinity range (10–30 ppt). Additionally, testing of the multiple antibiotic resistance indices (MARI) of *Vibrio* strains isolated from EHP-positive shrimp pond water and EHP infected shrimp hepatopancreas samples revealed that 50% of the tested samples were observed with MARI values over 2.0 indicating the development of antibiotic resistance in *Vibrio* spp. in shrimp ponds possibly due to the prolonged and frequent antibiotic exposure to antibiotics. As shrimp farms often adhere to legal restrictions against antibiotic use, the presence of high MARI in *Vibrio* isolates suggests an external source of antibiotic contamination. These findings highlight the need for improved disease management strategies in controlling EHP and associated *Vibrio* infections in shrimp aquaculture.

Keywords: *Hepatopancreas, Nested PCR, Penaeid shrimps, Physicochemical, SWP gene*

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EVALUATION OF FERTILIZATION-INDUCED CHANGES IN POPULATION DENSITY AND DIVERSITY OF ENDOPHYTIC FUNGI IN *Brassica juncea* (L.) CZERN & CROSS CULTIVATED IN DRY ZONE OF SRI LANKA

A.T. Pelawatta[1], H.S. Ferdinandez[1] and P.N. Yapa[1]*

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
**neelamanie@as.rjt.ac.lk*

Endophytes are microbes that reside within plant tissues without causing visible harm or disease to their host plant. Nearly all plants that have been studied so far exhibit some form of interaction with endophytic fungi, highlighting the widespread nature of this symbiotic relationship. This study aimed to assess the impact of fertilizer application on the population density and diversity of endophytic fungi in the roots of brown mustard (*Brassica juncea*) cultivated in the dry zone of Sri Lanka. A pot experiment was conducted with the mustard variety ANKM1 to evaluate the fertilizer effects. Two (02) different types of fertilizers, organic fertilizer (garden manure compost), inorganic fertilizer (N:P:K ratio; 2:1:1) and control (without any fertilizers) were prepared with 10 replicates. Ten (10) plants from each treatment were randomly uprooted at different stages of the growth and endophytic fungi were isolated on potato dextrose agar (PDA). Pure cultures were obtained by the hyphal tipping method and were used to determine the growth and the microscopic characteristics. Sanger sequencing of internal transcribed spacers 1 and 2 with 5.8S (ITS) region was carried out following successful DNA extraction, polymerase chain reaction (PCR) and gel electrophoresis. Isolation rate, colonisation rate and similarity index were calculated to determine their population diversity. Forty-three (43) culturable fungal isolates were reported across all growth stages: 15 isolates from early vegetative growth, 14 from late vegetative growth, and seven from the flowering stage. According to the basic local alignment search tool (BLAST) similarity search, isolates were identified as *Fusarium solani* (100%), *Phlebiopsis flavidoalba* (99.84%), *Letendraea helminthicola* (100%), *Chaetomium* sp. (100%), *Talaromyces* sp. (100%), *Talaromyces trachyspermus* (100%), *Hypoxylon fendleri* (100%), *Aspergillus micronesiensis* (100%) and *Corynespora cassiicola* (100%). *Aspergillus niger* and *Penicillium* sp. were identified by using fungal morphology. From identified fungal species, *F. solani* and *C. cassicola* were considered as phytopathogens and *Talaromyces trachyspermus* was a beneficial fungal endophyte. From all isolates, the RVE1.I1.B3 isolate had the maximum growth rate with a mean colony diameter (25.56 mm ± 0.5) after seven days of culturing. However, the endophytic fungal population did not show a direct correlation with plant growth rate. The highest isolation rate was reported from week 4 with organic fertilizer treatment (33%). The highest similarity coefficient (~72%) was observed within two populations of weeks 2 and 4. These findings highlight a diverse endophytic fungal community in mustard variety ANKM1 roots, where interactions between phytopathogens and beneficial species may significantly influence plant health and productivity.

Keywords: *ANKM1, Endophytic population, Brassicaceae, Root microflora, Fertilizer*

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PHENOTYPIC AND GENOTYPIC CHARACTERISATION OF ANTIMICROBIAL RESISTANCE IN *Campylobacter jejuni* ISOLATED FROM POULTRY PROCESSING PLANTS IN SRI LANKA

M.P. Rankoth Gedara[1,2], G. Weerasooriya[2]*, H.M.T. Dulakshi[2], P.S. De Alwis[2], P.N. Yapa[1] and M.A.R. Priyantha[2]

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
[2]Bacteriology Division, Veterinary Research Institute, Peradeniya, Sri Lanka.
**gayaniw13@gmail.com*

Campylobacter jejuni is a major zoonotic foodborne pathogen commonly spread through poultry. The rising antimicrobial resistance (AMR), especially multidrug resistance (MDR), in *Campylobacter* spp. poses a serious health threat to the public. Despite global concern, comprehensive data on AMR patterns in *C. jejuni* in Sri Lanka are limited. The poultry industry plays a crucial role in food security and the country's economy. This study aimed to characterise phenotypic and genotypic resistance patterns in *C. jejuni* isolated from poultry processing plants in Sri Lanka. A total of 33 *C. jejuni* isolates collected from whole chicken carcass washings and environmental samples were analysed through minimum inhibitory concentration (MIC), antibiotic susceptibility testing (AST), and gene screening using PCR for five resistance genes. Both MIC and AST profiling revealed high levels of resistance to nalidixic acid (100% and 96.97%), tetracycline (90.91% and 93.94%), and ciprofloxacin (93.94% and 84.85%), respectively. The susceptibility testing for sulfamethoxazole-trimethoprim showed moderate resistance of 51.52%. Notably, 78.80% *C. jejuni* isolates exhibited multidrug resistance in the present study. Resistance was consistently higher within environmental samples compared to carcass washings across all methods. Gentamicin showed a significant difference ($p<0.05$) in resistance between carcass washings and the environmental samples. However, the resistance to gentamicin in MIC was 87.88%, and in AST it was 63.64%. Therefore, the resistance patterns were not significantly different between the MIC and AST. AMR of *C. jejuni* isolates phenotypically did not show a significant difference over any method, however, MIC proved more precise for *C. jejuni* than AST in detecting borderline or high-level resistance that AST failed to identify. In support of these findings, MIC_{50} and MIC_{90} values respectively were 128 and >256 µg/mL for nalidixic acid, 32 and 64 µg/mL for tetracycline, 16 and >16 µg/mL for ciprofloxacin, and 8 and >32 µg/mL for gentamicin. These quantitative benchmarks emphasise the higher sensitivity of MIC testing over AST in resistance determination. The genotypic method revealed *tetA* as the most prevalent gene (42.42%), followed by *tetB* and *sul1* (24.24% each), and *gyrA* (21.21%) among the isolates. Resistance patterns demonstrated significant variations between genotypic and phenotypic levels, because of either limitations in the identification of genes or the presence of other resistance mechanisms. The findings of this study highlight the significant burden of MDR in *C. jejuni* in poultry processing plants in Sri Lanka. Therefore, AMR surveillance in *Campylobacter* is urgently needed in the animal food industry.

Keywords: *Campylobacter, Antimicrobial resistance, MIC, Gene screening, MDR*

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OPTIMISATION OF HAIRY ROOT INDUCTION IN VARIOUS PLANT EXPLANTS USING TWO *Rhizobium rhizogenes* ISOLATES AND ALTERNATIVE INDUCER TREATMENTS

L.P.T.C. Ihaladeniya[1], K.W.Y.R. Kalamulla[1] and P.N. Yapa[1]*

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
**neelamanie@as.rjt.ac.lk*

Hairy root cultures (HRC) technology stands as a valuable approach in plant biotechnology with global applications, yet their adoption in Sri Lanka remains limited due to persistent local challenges. This study aimed to establish, evaluate and optimise the cost-effective HRCs, induced by two indigenous isolates of *Rhizobium rhizogenes* using various locally available explants under different alternative plant-derived transformation inducers. Two isolates of *R. rhizogenes* were isolated and identified from two different hairy root diseased plants: *Capsicum annuum* cv. KA2 (Isolate 1) and a *Solanum lycopersicum* cv. Thilina (Isolate 2) for the establishment of HRCs. As the first part of the experiment, optimal selection of explants, infection method, and culture medium was carried out using *R. rhizogenes* Isolate 1. Hairy roots were observed only in the *Daucus carota* L. cv. Lanka Carrot discs, *Solanum tuberosum* cv. Golden star sprouts and *Solanum torvum* leaf blades cultured in ½ MS solid medium with direct infection of the bacterium. As the second part of the experiment, the effect of three factors: explants, *R. rhizogenes* isolates and inducers on hairy root induction were evaluated, using explants selected from the 1st experiment (*D. carota, S. tuberosum* and *S. torvum*), two isolates of *R. rhizogenes*: Isolate 1 and Isolate 2, and alternative inducers (Cinnamic acid and *Capsicum annuum* cv. KA2 plant sap) respectively. According to the experiment, *D. carota* was found as the most effective explant source for transformation efficiency (TE), which was calculated as the percentage of explants formed hairy roots out of the total number of explants infected with *R. rhizogenes* as it significantly outperformed *S. tuberosum* with mean TE difference (ΔTE) of -37.78 ($p < 0.05$). Cinnamic acid treatment is significantly more effective than plant sap treatment (ΔTE = 20.0) and no-inducer treatment (ΔTE = 30.0; $p = 0.00$), while bacterial Isolate 2 showed significantly higher TE compared to Isolate 1, with a mean difference of ΔTE = 13.89 ($p = 0.002$). *Daucus carota* had the most effective TE when treated with cinnamic acid, as it significantly outperformed *S. tuberosum* untreated, with a mean ΔTE of - 41.35 ($p = 0.00$). Among three factor combination treatments, *Daucus carota* L. cv. Lanka Carrot was identified to be the most suitable explant exhibiting the highest transformation efficiency of 80 ± 0.0 % and the highest average number of hairy roots per transformed explant (3.75 ± 0.25) and 0.1082 ± 0.001 mm/day of highest hairy root growth rate under the treatment combination of cinnamic acid and bacterial Isolate 2. However, the combined interaction of explant source, inducer, and bacterial strain was not statistically significant ($p > 0.05$) under the tested conditions. The established protocol enhances transformation success in resource-limited settings and opens avenues for future studies to refine HRC technology in Sri Lanka, promoting its adaptability for the rapid and ready supply of plant materials that can be used in agricultural, scientific and industrial exploitation.

Keywords: *Rhizobium rhizogenes, Hairy root induction, Transformation efficiency, Transformation inducers, Bacterial strain*

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POTENTIAL ACCELERATED BIOTRASNFORMATION OF PETROCHEMICAL PLASTIC SURFACES BY ANAEROBIC DIGESTER SLUDGE MICROORGANISMS

P.M.A.C. Muhandiram[1], B.M.C. Somasiri[1], B.R.C.M. Basnayaka[1], C.M. Jayathilake[1] and E.Y. Fernando[1]*

[1]Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
**eustace6192@as.rjt.ac.lk*

Plastics have been a vital part of human life for years, offering innovative solutions to various needs. However, the widespread use of petrochemical plastics has become one of the major environmental issues, contributing to pollution and posing long-term ecological risks. Plastics, derived from petrochemicals are predominantly non-degradable. Recycling these post-consumer plastics faces challenges because they resist biodegradation in the natural environment. Despite a few previous studies suggesting surface biotransformation of petrochemical plastics in anaerobic digestion (AD) systems, the underlying mechanisms of plastic surface chemical transformations are poorly understood. Thus, this study examined the potential of AD system microorganisms to biotransform plastics as an eco-friendly and low-cost alternative. For this study, a laboratory-scale AD system was prepared and maintained, which was initially inoculated with sludge samples from an anaerobic treatment unit. The reactor produced 89.2% methane of total headspace gas within 30 days, confirmed by GasBoard 3200 Plus handheld biogas analyser, with the production of 176.4 ± 29.9 mL of cumulative methane volume with a yield coefficient of 1.74 ± 0.21. Three varieties of the most commonly used petrochemical plastics, Polypropylene (PP), Polyvinyl chloride (PVC), and Polyethylene (PE) were used, and after a 50-day incubation period, the plastics were recovered from AD sludge to measure any significant mass loss. The Kruskal–Wallis test analysis showed a significant mass loss ($P < 0.05$) in PVC pieces with a 1.1 ± 0.16 mg average mass loss, where PP (0.05 ± 0.02 mg, $P > 0.05$) and PE (0.15 ± 0.06 mg, $P > 0.05$) did not show any significant mass loss. Raman spectroscopy was used to assess the surface characterisation of all plastic types, where spectra overlaid from PVC samples on different days showed temporally increasing new peaks at 1729 cm^{-1}, corresponding to C=O stretching vibrations. PP samples also showed a significant new Raman shift in the spectral range of C=C stretching vibrations in the region of 1512 cm^{-1}. Out of three samples, atomic force microscopy (AFM) surface topography images of PVC samples showed a relatively broad distribution of topographical variation, whereas control samples showed an average roughness amplitude of ~100 nm. This surface roughness was assumed to be associated with the manufacturing process. The roughness measurements recorded after 30 and 50 days of incubation in digester sludge remained within a similar range, but with a time-dependent decrease in the average roughness amplitude. After 30 days, the average roughness amplitude was approximately 90 nm, while after 50 days, the average roughness amplitude had decreased to around 65 nm. Further, surface analysis by phase-contrast microscopy of three different plastic pieces showed evidence of polymer digestion, including surface smoothening, embrittlement for all plastic types. Thus, this study concludes that alterations to the overall surfaces of all polymers and newly observed biodegradation of PVC suggesting a biotransformation, leading to biodegradation, by AD system microbes. Furthermore, it could be concluded that the AD system treatment of certain types of plastic waste has the potential to remove or partially transform them.

Keywords: *Biodegradation, Petrochemical plastics, Anaerobic digester, Raman spectroscopy*

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CHEMISTRY

ELECTROCHEMICAL DEPOSITION AND CHARACTERIZATION OF TUNGSTEN OXIDE-COATED TITANIUM ELECTRODES

M.C. Hettiarachchi[1*] and A.M.C. Herath[1]

[1]Department of Chemical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
** shikamauli@gmail.com*

This study dives into the electrochemical deposition and characterization of titanium electrodes (Ti) coated with tungsten oxide (WO_3). The prime focus was to explore the electrochemical characteristics of tungsten oxide films in various conditions, such as varying electrolytes, pH, and deposition times. Electrochemical deposition was utilized to coat the titanium electrodes. An electrolyte solution was made by dissolving sodium tungstate ($Na_2WO_4 \cdot 2H_2O$) , trisodium citrate dihydrate ($Na_3C_6H_5O_7 \cdot 2H_2O$), and boric acid ($H_3BO_3$) in phosphoric acid($H_3PO_4$). The pH was brought to 8.3 with 1 M NaOH, and the solution was warmed to 70 °C. A DC potential of 3 V was applied constantly for 1 or 2 hours. The appearance of a distinct yellow color on the electrode surface indicated successful deposition of tungsten oxide. Cyclic voltammetry was employed to study the electrochemical behavior of the deposited electrodes in different electrolytic mediums, i.e., 0.1 M H_2SO_4, HCl, NaCl, Na_2SO_4, and NaOH. The findings displayed excellent redox activity in acidic mediums, i.e., H_2SO_4 and HCl, whereas low current responses were shown in alkaline mediums such as NaOH, revealing the decrease in electrochemical reactivity. The pH effect was thereafter explored in a 0.1 M H_2SO_4 solution between pH levels of 1 and 4. The results showed that the oxidation peak currents and the reduction peak currents both decreased as there was an increase in pH, hence validating the proton-dependent redox property of the tungsten oxide film. The effect of deposition time on electrode performance was also studied. Electrodes deposited for 2 hours possessed more defined redox peaks than those deposited for 1 hour, reflecting superior electroactive surface area and conductance. Color intensity of the deposited film also grew with deposition time, consistent with the formation of thicker or denser film. These findings demonstrate that deposition conditions significantly influence electrochemical properties of tungsten oxide-coated titanium electrodes.

Keywords: *Tungsten oxide, Titanium electrode, Electrochemical deposition, Cyclic voltammetry, PH effect, Deposition time, Electrolyte study*

TEMPERATURE-DEPENDENT ELECTROCHEMICAL CHARACTERIZATION OF ZIRCON IN VARIOUS ELECTROLYTES

K.M. Nisansala[1]* and A. M. C. Herath[1]

[1]Department of Chemical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka
**nisansalamadumi353@gmail.com*

Zircon ($ZrSiO_4$) is a naturally occurring silicate mineral renowned for its exceptional chemical stability, thermal resistance, and structural strength, making it a promising candidate for high-level electrochemical applications. However, its intrinsic trace impurities, particularly iron, can significantly distort its redox behavior, obscuring its inherent electron transfer properties and degrading performance. This dissertation presents a systematic investigation of the electrochemical behavior of zircon, with an emphasis on optimizing redox activity through impurity elimination and examining its responsiveness in various physicochemical environments. An oxalic acid leaching method was developed and optimized for the selective extraction of iron impurities from natural zircon without compromising its crystallographic framework. Key process variables, including acid concentration, leaching time, and heat treatment, were systematically varied to achieve maximum iron extraction efficiency. The electrochemical behavior of both unpurified and purified zircon was examined using cyclic voltammetry (CV) in different acidic and neutral electrolytes to evaluate redox performance. CV in 0.1 $moldm^{-3}$ H_2SO_4 revealed well-defined redox peaks at potentials of 0.529 V (oxidation) and 0.313 V (reduction) vs. Ag/AgCl. These observations underscore the significant effect of electrolyte composition on the electrochemical signature of zircon, highlighting its sensitivity to pH and the ionic environment. Thermal analysis further indicated that elevated temperatures accelerate charge transfer kinetics, pointing to a thermally activated electron transfer process. The combined effects of electrolyte nature and temperature were shown to play a crucial role in modulating zircon's electrochemical response, with implications for its application under varying operational conditions. Overall, this research elucidates the complex interplay between compositional purity, electrolyte chemistry, and temperature in governing the redox characteristics of zircon. The findings position zircon as a versatile and tunable electroactive material suitable for diverse applications, including environmental sensing and energy conversion. This work establishes a framework for the future design, functionalization, and integration of zircon-based systems in next-generation electrochemical technologies.

Keywords: *Zircon, Electrochemical behaviour, Thermal analysis, Oxalic acid leaching, Cyclic voltammetry*

ISOLATION AND CHARACTERIZATION OF DISSOLVED ORGANIC CARBON IN GROUNDWATER

U. D. S. M. Rathnasooriya[1*] and A. M. C. Herath[1]

[1]Department of Chemical Sciences, Faculty of Applied Sciences Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
[*]Sandunim330@gmail.com

Humic substances are complex biomolecules formed from the degradation of organic matter through biological and chemical processes. They are categorized based on solubility as fulvic acid (FA), which is soluble at all pH levels, humic acid (HA), soluble at pH above 2; and humin, which is insoluble. This study aims to elucidate the isolation and characterization of fraction of humic substances from tube well water in order to determine its suitability for human consumption. The isolation process is carried out using XAD-8 macroporous non-ionic resin which is particularly efficient at adsorbing humic substances at low pH levels. The water samples were acidified to pH 2 using concentrated HCl and eluted with 0.1M NaOH. UV-Visible and FTIR spectroscopic methods are used to determine the functional groups present in the extracted fractions. Humic substances typically exhibit three characteristic UV absorption bands as local excitation (LE) band (λ<190 nm), Benzenoid (Bz) band (λ 190-240 nm), and $\pi \rightarrow \pi^*$ transitions (ET) band (λ> 240). The (E_{ET}/E_{Bz}) correlates with the degree of substitutions of O-containing functionalities to aromatic ring structure. The (E_{ET}/E_{Bz}) ratio increases with the degree of substituted aromatic constituents in the HS structure. The (E_{ET}/E_{Bz}) ratio higher in HA (0.82) than FA (0.80). In FTIR analysis further confirmed functional group differences, with a prominent band 2922 cm^{-1} appearing exclusively in HA and aromatic. C-H stretching band at 3131 cm^{-1} observed in HA but absent in FA. This study aims to provide the nature and composition of dissolved organic matter in groundwater, contributing to the broader understanding of its environmental behaviour and potential impact on water quality in the region.

Keywords: *Dissolved organic carbon (DOC), Humic acid (HA), Fulvic acid (FA)*

FORMULATION AND EVALUATION OF SHAMPOO BARS (SOLID SHAMPOO)

R. M. N. P. Rathnayake[1*], S.A. Senevirathne[1] and N. B. Jayarathne[1]

[1]Department of Chemical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
**piumirathnayake1998@gmail.com*

Shampoo bars offer a sustainable alternative to liquid shampoos by eliminating the need for plastic bottles, significantly reducing plastic waste. A biodegradable material such as paper or cardboard can be used instead of the plastic container. Shampoo bars are more economical than liquid shampoos, as they last longer and provide better value for money. This research aims to formulate and evaluate an effective, eco – friendly shampoo bars that minimizes plastic waste while ensuring cost efficiency and hair care benefits. Since converting commercially available liquid shampoo directly into a solid bar would compromise its consistency and appearance, the shampoo bars were made using the heat saponification method. First, heat saponification was performed using EDTA and citric acid with commercially available liquid shampoo. The amount of commercially available liquid shampoo was increased from 40% (w/w) to 50% (w/w) to improve the quality of the results of stability testings. The same procedure was repeated using sodium lauryl sulphate (SLS), citric acid, EDTA, and glycerol instead of commercially available liquid shampoo. Due to the adverse effects of SLS on the human body, the next experimental method was to use natural ingredients (mainly soap nut) instead of SLS. Shampoo bars made using rice husk powder as a natural filler had a relatively higher mechanical strength, which helped minimize cracking that occurs when the shampoo bar is used for a long time. It's fibrous, rigid particles were helped bind the ingredients together more uniformly by reducing the internal stress during drying. One significant drawback noted with using rice husk filler in shampoo is that those fine particles often stick around on the scalp even after rinsing. Scum formation is a frequent problem seen in shampoos that use traditional soaps and sodium lauryl sulphate (SLS), particularly when they're mixed with hard water. The use of EDTA and citric acid has been shown to greatly minimize scum build up in shampoo formulations. By grabbing hold of calcium and magnesium ions, EDTA and citric acid keep the cleansing agents soluble, leading to a clearer shampoo that foams better and rinses more effectively. The scalp – friendly pH range (4.5 – 6.5) was observed for all the 5% (w/v) and 10% (w/v) shampoo formulations. The percentage of water content in each bar was between 10% - 15% and did not exceed the optimum value (15%). In the solubility test conducted by gravimetric analysis, moderate solubility was observed in all shampoo bars except for the bars that used rice husk powder. When determining the lathering power and lathering stability using the volume of lather formed in the measuring cylinder and its half-life, the percentage of lathering stability ranged between 60% - 75% for various shampoo formulations. The sebum removal test confirmed that the cleansing efficiencies were at optimum values. In conclusion, shampoo bars offer comparable cleansing properties while reducing plastic waste and promoting sustainable personal care practices.

Keywords: *Shampoo Bar, Scum formation, Biodegradability, Cleansing, Consistency*

DEVELOPMENT AND CHARACTERIZATION OF BIODEGRADABLE CASSAVA STARCH- BASED POLYMERS FOR SUSTAINABLE PACKAGING APPLICATIONS

U. G. N. Thamaransi[1*], S. A. Senevirathne[1] and N.B. Jayarathne[1]

[1]Department of Chemical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihinthale, Sri Lanka
[*]Nethminigamage44@gmail.com

Synthetic polymer materials, which are obtained from petroleum resources, are not biodegradable due to their resistance to degradation. Adverse environmental effects due to the accumulation of synthetic polymers have driven significant interest in biodegradable polymers. It has been reported that proliferation of microplastics poses serious risks to both human health and ecosystems, as they can be ingested by marine organisms and accumulate throughout the food chain. Biodegradable polymers offer a promising solution by reducing waste, safeguarding natural habitats, and supporting a more sustainable future. This research explores the sustainable alternative for the synthetic polymers and its characterization and potential applications. The major natural source is a Cassava (*Manihot esculenta*) starch, while Acetic acid has been used to modify the amylose structure. Glycerol was used as a plasticizer. Gelatinization represents a fundamental physiochemical transformation that occurs during the preparation of starch-based polymers, involving the disruption of granular structure and the leaching of amylose into the continuous phase. Trisodium Phosphate is added as a cross-linking agent, which plays a pivotal role in flexibility. The composition of the TSP was changed to 5%, 10%, 15%, and 20%. Polymers incorporated with Methanol and Isopropyl alcohol exhibit reduced microbial contamination and demonstrate enhanced physiochemical properties of significance. This study further investigates the influence of cross-linking agents on the physiochemical characteristics of biodegradable polymeric materials. The water solubility, water absorption capacity, moisture content, dry matter density, and biodegradability of modified Cassava starch biopolymers were determined. Reducing the water content in the biopolymer formulation decreases the drying time and enhances the hardness of the resulting material. Experimental findings demonstrate improved water stability, evidenced by a reduction in water solubility to below 30% at room temperature and a water absorption capacity of less than 25%. Furthermore, the polymers exhibit moderate biodegradability, with over 50% of the material degrading under standard conditions. These properties render the biopolymers well- suited for packaging and various industrial applications.

Keywords: *Cassava starch, Tri-Sodium Phosphate, Biopolymer, Biodegradable, Eco-friendly material*

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DEVELOPMENT AND EVALUATION OF A HERBAL SKINCARE GEL FROM TRADITIONALLY USED PLANT EXTRACTS: PHYTOCHEMICAL PROFILING, BIOACTIVITY ASSESSMENT, AND SENSORY EVALUATION

W.M.R.S.S. Werellagama[1*], E.M.R.K.B. Edirisinghe[1] and D.S. Shanuke[2]

[1]Department of Chemical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka
[2]National Science Foundation, 47/5 Maitland Place, Colombo 07, Sri Lanka
**shashinisaharawerellagama@gmail.com*

The global demand for plant-based skincare is increasing due to their safety, cost-effectiveness, and potential as natural bioactive compounds for addressing skin conditions like wrinkles and premature aging. This study aimed to formulate a herbal skin care gel using plant species traditionally employed in Sri Lankan household remedies. Seventeen medicinal plants—*Moringa oleifera, Punica granatum, Aegle marmelos, Flueggea leucopyrus, Psidium guajava, Psidium cattleyanum, Elaeocarpus serratus, Euphorbia antiquorum, Azadirachta indica, Aloe vera, Centella asiatica, Emilia sonchifolia, Asparagus racemosus, Ixora coccinea, Cassia alata, Momordica dioica,* and *Dialium ovoideum* were investigated for their phytochemical composition, antioxidant and antibacterial activity. Plant extracts were obtained via solvent extraction using a 1:1 (v/v) methanol:dichloromethane system. The crude extract was recovered using rotavapor at 45 °C. Antioxidant activity was assessed using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay. Furthermore, Gas Chromatography-Mass Spectrometry (GC-MS) analysis and phytochemical screening was conducted to identify the major phytoconstituents in extracts. The antibacterial activity of the plant extracts was also tested against standard cultures. Phytochemical screening confirmed the presence of flavonoids, alkaloids, phenolics, tannins, terpenoids, saponins, carbohydrates, sterols, and triterpenes across all samples. The highest antioxidant activity was recorded by the extract of *E.serratus* fruit (73.75 ± 0.02%) and leaf (54.79 ± 0.14%). The highest but moderate antibacterial activity was observed by leaf extract of *E.serratus*, followed by *P.cattleyanum* against *Staphylococcus aureus*. GC-MS results revealed unique chemical compounds with antioxidant properties in leaves such as Humulene in *P.guajava, trans*-4- Methoxychalcone in *E.serratus,* Caryophyllene oxide in *P.cattleyanum,* 1-methyl-1H-Pyrrole in *F.leucopyrus,* (3.alpha.)-D:A-Friedooleanan-3-ol in *E.antiquorum,* 2,5-bis (3,4-dimethoxyphenyl) tetrahydro-3,4-dimethyl-,[2R-(2.alpha.,3.beta.,4.beta.,5.alpha.)]-furan in *P.granatum,* 4-Hydroxy-3-methylacetophenone in *A. indica* and fruits such as 2-oxo-butanoic acid in *I.coccinea,* Lupeol in *M.dioica.* Based on these promising bioactivities, herbal skincare gel from both fruit and leaf extracts of *E.serratus* were formulated. Sensory evaluation of the formulated products was conducted using 30 semi-trained panellists and a 7-point hedonic scale to determine the most preferred gel formulation. The formulation containing 93.91% of *E.serratus* fruit water extract received the highest overall acceptance. Furthermore, comparative analysis with a commercial skincare product revealed no statistically significant differences ($p > 0.05$) in key physical attributes, including absorption rate, density, adhesion, and consistency. The gel formulated with *E.serratus* fruit extract demonstrated superior antioxidant activity compared to the leaf extract-based formulation. However, the leaf extract gel exhibited the highest sun protection factor (SPF), recorded at 18.09 ± 0.32. These findings highlight the potential of *E.serratus* fruit and leaf extracts as promising natural ingredients in skincare product development, offering strong antioxidant and antimicrobial properties with high sensory acceptance and high SPF. Future investigations will focus on optimizing the formulation by exploring synergistic combinations of fruit and leaf extracts to further enhance bioactivity and sensory appeal.

Keywords: *E.serratus, GC-MS, Antioxidant, Phytochemical, Skin-gel*

ANTIOXIDANT ACTIVITY, PHYTOCHEMICAL SCREENING, AND GC-MS PROFILING OF SELECTED SRI LANKAN TEA VARIETIES AND THEIR POTENTIAL IN OXIDATION PREVENTION

J. K. P. Malshika[1*], E. M. R. K. B. Edirisinghe[1] and H. P. S. Senarath[2]

[1]Department of Chemical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka
[2]Department of Food Science & Technology, Faculty of Livestock Fisheries & Nutrition, Wayamba University of Sri Lanka, Makandura, Gonawila, Sri Lanka
[*]piyumimalshika99@gmail.com

Tea (*Camellia sinensis*) is a widely consumed beverage renowned for its diverse phytochemical composition and potent antioxidant properties. The study aimed to analyse 24 commercially available tea varieties belonging to four groups, i.e., black, green, organic, and herbal teas, to identify key bioactive compounds responsible for their functional health benefits. Methanol and dichloromethane were used as the solvents for extraction, and the solution was concentrated using a rotavapor (Buchi R- 114, Switzerland) at 40°C and 50 rpm of rotating speed. The antioxidant activity was assessed using the DPPH (1,1-diphenyl-2-picrylhydrazyl) free radical scavenging assay using a UV-visible spectrophotometer measuring at a 517 nm wavelength. The phytochemical profile of the methanolic extract of the tea varieties was obtained by Gas Chromatography – Mass Spectrometry (GC-MS) analysis. Based on the DPPH results and phytochemical profiles obtained by GC-MS, six tea varieties were selected and applied to the fish oil model, stored for 3 weeks, to assess the total oxidation value (TOTOX) by measuring peroxide value (PV) and p-anisidine value (p-AV). Additionally, the fatty acid composition of the fish oil was analysed by GC-MS to further evaluate the antioxidant potential of the selected tea varieties. Phytochemical screening tests revealed the tea samples' abundance of alkaloids, flavonoids, polyphenols, saponins, and terpenes. Among the 24 tea varieties analysed, six samples demonstrated superior antioxidant activity in the DPPH free radical scavenging assay. The tea variety with the best antioxidant activity was 26-KRT at 85.39%, followed by 21-BGT at 63.54%, 9-GTGPP at 61.15%, 3-LGTC at 59.71%, 7-OGT at 57.73%, and 6-PGT at 56.24%. The GC-MS analysis of the tea varieties identified 120 different compounds, including 1,2,3-benzenetriol, 1-pentadecene, hexanoic acid, n-hexadecenoic acid, Vitamin E, phytol, 9,12,15-octadecatrienoic acid (Z,Z,Z)-, and 9,12- octadecadienoic acid (Z,Z)-. Caffeine was the main constituent among the compounds identified by GC-MS in all tea varieties except in herbal tea types such as Weniwelgata tea, Slim Apple tea, Mature tea, Pure Camomile tea, and DETOX. The Total Oxidation (TOTOX) values of fish oil samples treated with tea extracts were significantly lower than that of the control, indicating enhanced oxidative stability. Specifically, the TOTOX values were 231.43 for 3-LGTC, 294.04 for 9-GTGPP, 304.47 for 6-PGT, 306.85 for 26-KRT, and 495.24 for 7-OGT, compared to a substantially higher value of 2083.16 observed in the untreated control. The polyunsaturated fatty acids (PUFAs) in fish oils, including eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), were well preserved in samples treated with tea extracts. These results highlight the effectiveness of tea extracts in preventing lipid oxidation during storage, demonstrating their strong antioxidant potential.

Keywords: *Camellia sinensis, Gas Chromatography-Mass Spectrometry, Antioxidants, DPPH*

BIOSYNTHESIS OF COPPER NANOPARTICLES USING *Syzygium cumini* AND THEIR CATALYTIC ACTION IN METHYLENE BLUE DEGRADATION

M.F. Shiraafa[1]*, S.A. Senevirathne[1] and N.B. Jayarathne[1]

[1]Department of Chemical Sciences, Faculty of Applied Sciences Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
**shiraafa.m@gmail.com*

The biosynthesis of copper nanoparticles using plant extracts is an environmentally friendly and cost-effective alternative to conventional synthesis methods. In this study, Copper nanoparticles were synthesized using *Syzygium cumini* (Java plum) leaf extract, which acts as a natural reducing and stabilizing agent due to its rich content of polyphenols and flavonoids. The synthesis was visually confirmed by a colour change from pale yellow to brown, indicating nanoparticle formation, and further characterized by UV-Vis spectroscopy, revealing a Surface Plasmon Resonance (SPR) peak around 535 nm. The average particle size and Polydispersity index (PDI) concludes that the produced Copper nanoparticles are monodispersed. The catalytic potential of the biosynthesized Copper nanoparticles was investigated by assessing their ability to degrade methylene blue dye (blue colour) to leucomethylene blue(colourless), a common organic dye and environmental pollutant, in an aqueous medium using sodium borohydride ($NaBH_4$) as a strong reducing agent. Sodium borohydride, being strong reducing agent is not able to reduce methylene blue in the absence of catalyst, indicating the catalytic efficiency of Copper nanoparticles. The reaction was monitored using UV-Vis spectroscopy, showing a rapid decrease in the absorbance peak at 664 nm, confirming efficient dye degradation. The Copper nanoparticles exhibited high catalytic efficiency, achieving up to maximum of 94% methylene blue degradation within 180 minutes, particularly under UV-light-assisted conditions under different concentrations of methylene blue and amounts of Copper nanoparticles at ambient temperature and pH 07. According to the kinetic studies, copper nanoparticles catalytically reduced methylene blue in a pseudo-first-order manner. These findings demonstrate that biosynthesized Copper nanoparticles are highly effective Nanocatalysts for environmental remediation, offering a sustainable solution for wastewater treatment applications. *Syzygium cumini*-mediated Copper nanoparticles synthesis provides a promising route for producing functional nanomaterials with excellent catalytic properties. The findings reinforce the importance of integrating phytochemistry with nanoscience for environmental and industrial applications.

Keywords**:** *Copper nanoparticles, UV-Vis spectroscopy, Methylene blue, Sodium borohydride (NaBH4)*

COMPUTING

VERIFICATION OF LEGAL DOCUMENTS IN JUDICIAL SERVICES USING BLOCKCHAIN TECHNOLOGY

D. S. M. Jayasooriya[1*], N. M. A. P. B. Nilwakka[2] and K. M. D. Prashadika[2]

[1]Department of Physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale
[2]Department of Computing, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale
shiharajayasooriya@gmail.com

The increasingly widespread presence of document forgery within the Sri Lankan judicial system requires a secure and efficient method for verifying legal documents. Traditional methods relying on manual checking are time-consuming, liable to human error and susceptible to corruption. The main focus here is on the facts, such as a verifier re-quoting a document that has been authenticated by another, altering its contents, or re-applying official seals and signatures that have been used. This study proposes a blockchain-based solution for verifying legal documents to address these challenges to address these challenges.

The proposed system ensures decentralization and immutability and supports Ethereum smart contracts for storing SHA-512 hash values. In the research method, a hash value is generated for the entire content of the uploaded legal document. After this hash value is saved on the blockchain, the integrity of the documents is verified using the saved hash value. After verifying the document, it can be determined whether the document is forged or authentic. A QR code containing the verification and the verifier details is also generated, and it can be used as a digital signature. The verifier of the legal document must be a qualified lawyer engaged in judicial services in Sri Lanka, who has been sworn in as an Attorney-at-Law at the Supreme Court of Sri Lanka and registered with the Bar Association of Sri Lanka. The verifier must manually create a soft copy of the document as a PDF and upload it to the system. The remaining steps are completed automatically.

For this research, approximately 30 legal documents, in both English and Sinhala, were collected with the support of legal professionals. The documents covered a wide range of categories, including writs, plaints, affidavits, contracts, deeds, and notarial acts. Additionally, data were collected from discussions with lawyers to understand major document types and positions. The evaluation process involved analysing document patterns, font types, sizes, alignment, and authentication markers.

The system testing process used 59 testing scenarios. For performance testing, 24 English documents and 36 Sinhala documents were used. For usability testing, 7 legal professionals participated, and it was done by manually using the system. It has 100% accuracy for English-scripted documents, while it shows 91% accuracy for Sinhala-scripted documents because the system has difficulty in recognizing some Sinhala characters. Overall, the accuracy for both Sinhala and English scripted documents is 95%, calculated by averaging the two percentages above.

While exploring blockchain applications specific to the judicial sector, challenges within real-world legal frameworks were identified, and this study is the result of an effort to improve document integrity using advanced cryptographic hashing. This makes it more suitable for high-security applications in Sri Lankan judicial services. However, there are some limitations regarding document types and categories, such as English and Sinhala-scripted documents. Future work could involve enhancing Sinhala-scripted document verification and incorporating user authentication methods such as passkeys and OTPs. Additionally, the system could be further improved through the development of a mobile application to streamline and ease the verification process.

Keywords: *Document verification, Blockchain technology, SHA-512, Judicial service, Smart contract*

A NATURAL LANGUAGE PROCESSING-BASED APPROACH FOR AUTOMATIC UML CLASS DIAGRAM GENERATION

H.N.N.I. Nawarathna[1*], P.S. Palliyaguruge[1] and D. Prashadika[1]

[1]Department of Computer Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale.

[*]nuwanindu1998@gmail.com

Unified Modeling Language (UML) class diagrams are essential in visualizing and designing software systems. However, manually constructing these diagrams from natural language (NL) requirements is labor-intensive, error-prone, and highly reliant on the analyst's expertise. This research proposes an automated system for generating UML class diagrams from NL specifications using Natural Language Processing (NLP) techniques. The system consists of three primary modules: Linguistic Analysis, which restructures text using Subject-Verb-Object (SVO) conversion, pronoun resolution, and sentence splitting; Feature Extraction, which identifies UML components such as classes, attributes, and relationships (e.g., associations, inheritance, aggregation, composition); and Diagram Generation, which converts these elements into UML-compliant visual diagrams.

Natural language requirements were collected from a variety of academic and real-world sources, including case studies on Library Management and E-commerce platforms. These inputs were mapped to predefined UML diagrams to serve as ground truth for evaluation. The tool's performance was assessed using precision and recall metrics, achieving an overall precision of 80.68%, recall of 90.71%, and an F1-score of 85.36% in accurately identifying UML elements.

Despite its effectiveness, the system faces challenges in handling complex or ambiguous sentence structures, implicit relationships, and domain-specific terminology. Limitations also stem from SpaCy's dependency parsing and occasional misinterpretations caused by pronoun resolution and voice transformation. Future work will focus on improving implicit action recognition, class hierarchy refinement, and integrating Large Language Models (LLMs) to enhance semantic understanding and adaptability across domains.

This study contributes to automating the transition from informal NL requirements to formal software modeling, reducing manual effort while increasing consistency and accuracy in early-stage software design.

Keywords: *UML class diagrams, Natural Language Processing, Requirements engineering, Automated diagram generation, Feature extraction*

REAL-TIME STROKE RECOGNITION AND PERSONALIZED TRAINING RECOMMENDATIONS FOR BADMINTON PLAYERS

M.D.T Fernando[1]* and N.S. Weerakoon[1]

[1]*Department of Computing, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.*

**tharushadilmi@gmail.com*

Badminton is an explosive sport that requires players to have precise technical skills and quick movements, in contrast to many other sports that rely only on endurance. A player can enhance their performance through identifying their weaknesses and analysing their playing techniques. The ability to detect poor footwork during a smash enables player to prevent injuries and enhance their stroke performance. Recent deep learning approaches have shown potential for developing automated systems that precisely and effectively evaluate badminton stroke techniques. Still, current systems mostly perform offline analysis instead of real-time feedback during games or training sessions. Most current technologies cannot offer meaningful feedback to users unless they receive human coaching assistance. The research presents real-time badminton stroke recognition technology together with deep learning-based training methods and pose estimation techniques. The MediaPipe Pose framework serves as the system's detection tool because it quickly and efficiently identifies skeletal joints by extracting 33 vital body features from each video frame. The ConvLSTM (Convolutional Long Short-Term Memory) model receives these coordinates as input. The ConvLSTM network processes extracted pose landmarks to determine spatial and temporal information for stroke type classification precisely. The analysis of spatial and temporal relationships of body movement leads to better stroke type categorization accuracy. The researcher recorded more than 300 videos of six different strokes: backhand smash, backhand clear, backhand net, forehand smash, forehand clear, forehand net, and incorrect shot videos from the front view angle. The acquired dataset was pre-processed with the MediaPipe framework to extract pose landmarks, then this dataset was normalized and separated into training, validation, and testing sets. The ConvLSTM model achieved a training accuracy of 90.78% and a testing accuracy of 88.65%, more than the other deep learning models, proving its ability to recognize and classify multiple badminton strokes. After the classification process, a rating system method was implemented to determine the accuracy of each detected stroke. This system compares the classified strokes against a curated set of correctly and incorrectly performed strokes in the dataset. The algorithm provides a quantitative rating indicating whether the stroke was correct or incorrect, based on the comparison. Furthermore, the system offers personalized feedback explaining the reason for any incorrect classification, such as improper racket position, foot placement, or body posture deviation. This additional feedback enables players to understand their mistakes and make targeted improvements to their technique, enhancing the overall training experience. This research demonstrates the viability of using computer vision and deep learning for real-time, automated badminton stroke recognition and feedback creation. Future work will aim to further improve the model accuracy for multi-class classification of the strokes and develop an interactive user interface that provides real-time feedback.

Keywords: *Deep learning, Pose estimation, MediaPipe, ConvLSTM, Computer vision*

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A MACHINE LEARNING APPROACH TO PREDICTING OUTCOMES OF ONE-DAY INTERNATIONAL CRICKET MATCHES

S. Kanapathipillai*[1] and P.S. Palliyaguruge[1]

[1]*Department of Computing, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.*
**sivasorubyk@gmail.com*

After football, cricket is the second most popular sport in the world. It is played in more than 19 countries, and its popularity grows day by day. Cricket generates an extensive volume of structured and semi-structured data during each match, including ball-by-ball records such as runs scored, wickets taken, bowling economy, batting strike rates, player performance metrics, partnerships, and match events (boundaries, extras). Machine Learning techniques are fantastic at spotting patterns in large and complex datasets, making them a perfect fit for analyzing cricket data and predicting outcomes based on historical trends. Yet, there's still a gap when it comes to reliable tools that can accurately forecast the results of ODI matches, especially those that take into account intricate factors like batting partnerships, all while delivering top-notch performance. The factors chosen for predicting ODI match outcomes such as team, opponent, ground, toss result, batting and bowling decisions, runs scored, wickets lost, number of fours and sixes, extras conceded, run rate, average batting strike rate, wickets taken, best individual bowling performance, and batting partnerships were selected for their proven impact on match results, as highlighted in previous studies and cricket expertise. The Kaggle data source (Asia Cup Cricket Dataset 1984 – 2022) was chosen. Data was processed to several data preprocessing techniques, such as Null value handling and categorical encoding, to input data into the model, which is suitable for model training. For this research, we opted for the Extreme Gradient Boosting (XGBoost) algorithm to predict final match results. XGBoost stood out because of its excellent predictive capabilities, its knack for handling missing values, built-in regularization, and its resilience against overfitting, making it especially effective for structured, tabular cricket match data. It produced an accuracy of 98% as well. Furthermore, a regression-based ranking system was developed to assess player performance, as regression models are well-suited for predicting continuous-valued outcomes such as player contribution scores. For the toss decision, Support Vector Machine (SVM) was selected due to its strong performance in binary classification tasks, effectively handling high-dimensional data and small sample sizes. We integrated the predictive models into a user-friendly web application built with the Flask framework, using Pickle for model serialization. This application serves captains, coaches, analysts, and cricket enthusiasts by offering actionable insights for strategic planning, thus contributing to the expanding field of sports analytics and empowering data-driven decision-making in cricket.

Keywords: *Machine learning, ODI cricket prediction, XGBoost, SVM, Feature selection, Sports analytics, Ensemble learning.*

Acknowledgements: I extend my heartfelt gratitude to all the academic and non-academic staff at Rajarata University for their contributions to my academic journey.

ENHANCING WEB ACCESSIBILITY FOR PEOPLE WITH IMPAIRMENTS: A TOOL TO GUIDE WEB DEVELOPERS

R.A.D.P. Rajapakasha[1], L.N.C. De Silva[2], A.K.N.L. Aththanagoda[1] and W.B.P.N. Herath[1]

[1,]Department of Computing, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
[2]University of Colombo, School of Computing, Colombo, Sri Lanka.
**radp.rajapaksha@gmail.com*

Despite the existence of established standards such as the Web Content Accessibility Guidelines (WCAG), a significant number of websites remain non-compliant due to the developers' limited awareness and implementation challenges. This research addresses the critical issue of web accessibility for individuals with impairments, who rely heavily on digital content for academic purposes and daily needs. The main objective of this research is to design and implement an accessible, developer-friendly tool that identifies and provides real-time feedback on accessibility violations, aiming to increase WCAG compliance across websites. The methodology followed a structured approach beginning with the identification of key accessibility challenges-such as insufficient color contrast, missing alternative text, and improper heading structure-based on WCAG guidelines. A web-based tool was then developed using HTML, React.js, and Node.js to analyze website source code and evaluate accessibility under the four WCAG principles: Perceivable, Operable, Understandable, and Robust. To enhance the tool's capability, a Feed-Forward Neural Network (FNN) was trained on a custom dataset consisting of over 90000 labelled color combinations (compliant and non-compliant) curated from existing accessibility testing datasets and manually validated using WCAG color contrast thresholds (e.g., 4.5:1 for normal text). This allowed the tool to suggest alternative, compliant color schemes when issues were detected. The tool was evaluated using five public university websites selected to represent a range of design complexities. For benchmarking, each website was manually audited by accessibility experts based on WCAG 2.1 guidelines. Their assessment was then compared with the tool's automated findings to determine any overlaps and discrepancies. The tool's performance was then compared against these manual assessments, and its accuracy was calculated based on the percentage of correct matches, resulting in an accuracy rate of 86.66%. Although limitations exist concerning mobile responsiveness, the tool demonstrates significant potential to bridge the knowledge gap among developers and encourage inclusivity in digital environments. Future improvements aim to enhance mobile responsiveness and extend support for dynamic web content. This research contributes to a more equitable and user centered web experience for all individuals, particularly those with impairments, by aligning technical innovation with accessibility standards.

Keywords: *Accessibility awareness, Enhancement, Web accessibility, WCAG (Web Content Accessibility Guidelines), Web developers*

PERSONALIZED ADAPTIVE GAMIFICATION IN EDUCATION: ENHANCING STUDENT ENGAGEMENT AND PERFORMANCE THROUGH MACHINE LEARNING

U. L. Rathnayake*[1], W. B. P. N. Herath[1] and N. S. Weerakoon[1]

[1]Department of Computing, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihinthale, Sri Lanka
**laksithrathnayake456@gmail.com*

In e-learning, student engagement often struggles with high dropout rates and poor performance due to insufficient personalization and adaptation to diverse learning styles. Gamification has been proposed to address these challenges, but many one-size-fits-all implementations remain static and do not meet individual student needs. This study investigates whether a machine-learning-based Personalized Adaptive Gamification (PAG) system can accurately predict and enhance student learning performance and engagement. Specifically, the objectives include developing machine learning (ML) models to analyze each learner's behavior, pace of progress, and facial expressions to predict performance and engagement, designing a PAG framework that dynamically adapts gamification elements such as points, progress bars, badges, hints, motivational messages, and leaderboards based on these predictions, and evaluating the system's effectiveness against the Moodle LMS. To achieve these aims, three ML models were trained on separate datasets: a deep convolutional neural network (DCNN) using 35,887 facial images for real-time expression recognition, a convolutional neural network (CNN) using 2,120 images of online learners to analyze facial engagement patterns, and an artificial neural network (ANN) using 600 anonymized programming quiz records, including time spent, scores, and number of corrections to predict student performance. Each model's output was fed into a decision-making function that dynamically adjusts gamification elements in real time via the Gemini API, providing hints, help questions, and motivational feedback to struggling learners. A mixed-method evaluation compared the PAG system to the Moodle LMS using controlled experiments over one week with 20 IT and CS undergraduates. Each student completed two Bloom's taxonomy-aligned programming quizzes within 15 minutes: one using the PAG system and one using the Moodle LMS. Quantitative data, including quiz scores and time spent on a quiz, were recorded, and qualitative feedback on system preference and gamification elements was collected via post-quiz questionnaires. Results showed that the PAG system significantly outperformed Moodle, with 72.9% of questions answered correctly with PAG versus 61.8% with Moodle LMS, indicating a 17.9% performance improvement. Furthermore, students spent more time on the PAG quiz, indicating deeper engagement and 19 of 20 participants (95%) preferred the PAG system. Analysis of gamification elements revealed that supportive hints, a reverse timer bar, and the leaderboard were the most effective features. These findings demonstrate that ML-driven personalization of gamification substantially enhances engagement and learning outcomes. By tailoring feedback and incentives to each student's current state, the PAG approach improves the effectiveness of e-learning. Limitations include the small sample size and short testing duration, which may have influenced the results. Future research will extend the evaluation period, incorporate more varied learning activities, and refine model accuracy to enhance the system's adaptability and effectiveness. Overall, the proposed adaptive gamification system raised student engagement and performance, highlighting the value of personalized gamified design in e-learning.

Keywords: *Personalized adaptive gamification, Machine learning, E-learning, Student engagement, Academic performance*

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HEALTH PROMOTION

EFFECTIVENESS OF A HEALTH PROMOTION INTERVENTION TO REDUCE CYBERBULLYING AMONG STUDENTS AT THE COLLEGE OF TECHNOLOGY, ANURADHAPURA.

T. Thirulogasanker[1*], P.H.G.J. Pushpakumara[2] and L. Senarathna[1]

[1]Department of Health Promotion, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale.
[2]Department of Family Medicine, Faculty of Medicine & Allied Sciences
Rajarata University of Sri Lanka, Saliyapura.
**tharshayini98@gmail.com*

Cyberbullying is a repeated, intentional online harm that threatens youths' psychological and social wellbeing, particularly in educational settings. Despite increasing global research concerns, limited evidence exists on the effectiveness and sustainability of cyberbullying interventions among students in vocational education settings within Sri Lanka. Integrating health promotion principles such as enabling environments, youth empowerment, and participation offers a holistic approach to address determinants of cyberbullying. This study aimed to assess the effectiveness of a health promotion intervention in reducing cyberbullying incidents by addressing its underlying determinants among students at the College of Technology, Anuradhapura. A quasi-experimental single-group pre-post design comprising three phases was utilised. The study targeted vocational trainees aged 17-24 years, who had exited the traditional schooling system early and were at a heightened risk of cyberbullying. The sample included 52 full-time students of both genders, selected based on predefined inclusion criteria. The pre-intervention phase focused on developing study instruments and collecting pre-data using a mixed-method approach. The instruments included a pre-post-self-administered questionnaire that captured students' socio-demographic characteristics, prevalence of cyberbullying based on specific incidents, attitudes towards cyberbullying and knowledge of its underlying determinants. Qualitative data were collected through Focus Group Discussions (FGDs) using a structured topic guide. Informed by baseline insights, a four-month interventional phase, strongly rooted in health promotion principles was implemented. The intervention evolved as a process that was concurrently designed, implemented and evaluated with the active involvement of the students. Continuous facilitation was directed towards them throughout the intervention. A slogan, "spot it, stop it", was co-created by students to increase enthusiasm. Through twelve discussions, five determinants were prioritised, and six activities were designed. For example, the Reflective-Wall activity focused on addressing problematic social media usage and generating awareness of cyberbullying through captions. The Ice-Breaker activity aimed to address peer-networking and responsiveness by enhancing students' knowledge and attitudes in relation to cyberbullying. The post-intervention phase gathered quantitative data utilising the same tool. Changes in the prevalence of cyberbullying incidents, attitudes towards cyberbullying and knowledge of its determinants were assessed, with analysis conducted through descriptive statistics (frequency, percentage and chi-square). Qualitative data were gathered via FGDs using post-FGD guides and analysed thematically. Students experienced cyberbullying through impersonation, media mocking, insulting calls, device misuse, and spreading rumours, and engaged in behaviours such as media mocking, insulting calls, and mocking messages. For instance, the proportion of students reporting impersonation dropped from 80.8% before the intervention to 42.6% ($p = 0.000$) after. Likewise, those admitting to sending mocking messages reduced from 61.5% to 21.2% ($p = 0.000$) following the intervention. Students suggested that their ability to detect and respond to cyberbullying incidents increased, and that promoting positive peer interaction contributed to behaviour change, ultimately reducing the occurrence of cyberbullying within the setting. Thus, the delivery of a health promotion intervention was effective in reducing cyberbullying incidents among students at the College of Technology by addressing its determinants through empowering students with improved knowledge and attitudes. Also enhancing students' confidence and resilience against cyberbullying to promote an inclusive learning environment.

Keywords: *Cyberbullying, Cybervictimization, Health promotion, Determinants*

EFFECTIVENESS OF A HEALTH PROMOTION INTERVENTION IN ADDRESSING DETERMINANTS OF STRESS AMONG FIRST YEAR APPLIED SCIENCE UNDERGRADUATES AT RAJARATA UNIVERSITY OF SRI LANKA AS A PATHWAY TO IMPROVE MENTAL WELLBEING

A. Vidusika [1*], N.D. Wickramasinghe [2] and M. Fernando [1]

[1]Department of Health Promotion, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale

[2] Department of Community Medicine, Faculty of Medicine & Allied Sciences, Rajarata University of Sri Lanka, Saliyapura

[*]amanividusika97@gmail.com

Stress that is appropriate for a variety of human circumstances is a condition where an uncontrollable adverse challenge arouses and causes anxiety in an individual. The World Health Organization recognizes a strong relationship between mental wellbeing and stress that emphasizes that unmanaged stress is a risk factor for developing mental disorders, which in turn negatively impact overall wellbeing. Stress is a common problem for university students negatively affects their academic performance. In a global study by the American College of Health Association, more than 50% of university students reported feeling of stress at the time of study. Science undergraduates often experience higher levels of stress due to the demanding nature of their coursework which typically involves a combination of theoretical learning, practical laboratory work and research projects. Heavy workloads, exams, deadlines, low income backgrounds, peer pressure, relationships, new environment, poor time management, insufficient sleep, inadequate support systems are factors that contribute stress. The objective is to assess the effectiveness of a health promotion intervention to reduce normal life stress among first year undergraduates of the Applied Science Faculty, Rajarata University of Sri Lanka by addressing its determinants. A pre-test, post-test study design was used with a sample of 50 first year Applied Science undergraduates in RUSL by purposive sampling method. The study was conducted in 3 main phases: pre intervention phase, intervention phase, post intervention phase. In the pre intervention phase, conducted the pre data collection using a self-administered questionnaire. During the intervention phase, a health promotion intervention was mutually designed and delivered to the study participants. Determinants of stress were identified and prioritized by the undergraduates through continuous discussions and activities like awareness session, day line-up, marking the digital break charts, writing down the journaling, awareness session on stress were implemented to address those. The progress of the process was monitored using participatory methods based on mutually developed indicators. Post data collection was conducted using the same self-administered questionnaire and focus group discussions. The collected quantitative data were analyzed using descriptive statistics such as paired t test and qualitative data were analysed thematically. The study included first year undergraduates in the intervention group. No significant different were observed in the baseline socio-demographic factors including age, gender, ethnicity, religion. The biggest improvement was seen in practices related to stress, which showed a statistically significant change ($p=0.000$). The knowledge about stress did not show a significant change ($p=0.650$) and attitudes about stress also did not show significant change ($p=0.187$). The intervention significantly reduced student stress levels, evidenced by improved Perceived Stress Scale scores and p values. Undergraduates were enabled through facilitation to identify the 12 underlying determinants affecting their level of stress categorized under individual level, family level and academic level, lack of social contacts, low self-confidence, peer influence, language difficulties are some of them. The intervention contributed significantly to change stress related practices and improve overall mental wellbeing while also enhancing positive attitudes and maintaining a fair level of knowledge related to stress management.

Keywords: *Stress, Health promotion, Determinants, Mental wellbeing*

MATHEMATICS

A NEW APPROACH FOR SOLVING THE ONE-DIMENSIONAL CUTTING STOCK PROBLEM

A. V. L. H. Amarasinghe[1]* and E. M. U. S. B. Ekanayake[1]

[1]Department of Physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihinthale, Sri Lanka
**lakshanihansika02@gmail.com*

The Cutting Stock Problem (CSP) is a popular mathematical optimization problem that involves cutting large stock materials into smaller, predetermined sizes to fulfil customer demand, while minimizing material waste. This challenge is common in various industries such as paper, metal, fabric, glass, and wood manufacturing, where the efficient use of raw materials directly impacts operational costs. The CSP is NP-hard nature, and various solution approaches, including exact algorithms, heuristic, and meta-heuristic have been proposed to solve it. However, many of these methods still face challenges such as high computational complexity, difficult in handling large scale instances, or limited adaptability to real world constraints, thereby limiting their practical applications. CSP methods are generally classified based on dimensionality, and this work focuses on the One-Dimensional Cutting Stock Problem (1D-CSP). A novel heuristic approach, the Decreasing Even-Odd (DEO) method, is proposed here to solve the 1D-CSP. The DEO approach begins by sorting all pieces in descending order based on their size. Next, the selection process alternates, starting with the largest even sized piece, followed by the largest odd sized piece then the second largest even sized piece and continuing in this alternating pattern. This systematic arrangement improves the efficiency of the subsequent allocation process. After applying the even odd ordering, the First Fit algorithm is used to allocate the ordered pieces into stock lengths, minimizing waste and optimizing material usage. The first fit algorithm was chosen for the allocation step due to its simplicity, fast implementation and strong compatibility with the structured ordering provide by the DEO method. This combination ensures low computational, complexity while achieving effective material utilization, making it especially well-suited for industrial applications. The proposed method was tested on multiple benchmark datasets sourced from previous research in the cutting stock problem domain, along with randomly generated instances. The result of the DEO approach was evaluated by comparing the overall waste generated to other existing algorithms, such as First Fit Decreasing, Best Fit Decreasing, Next Fit, Best Fit and First Fit algorithms. The findings indicate that the proposed method achieves lower waste percentages while maintaining stock roll utilization comparable to the First Fit, Best Fit, and Next Fit algorithms. Also, it yields results equal to First Fit Decreasing and Best Fit Decreasing, which are currently considered the best heuristic methods available. The proposed method provides an effective solution to the 1D-CSP, achieving competitive results with minimal complexity. Future research could explore its applications to larger, more complex instances or evaluate further improvements to enhance its efficiency and relevance in industrial settings.

Keywords: *One dimensional cutting stock problem, NP-hard, Heuristic approach, Decreasing even-odd method, First fit algorithm*

REFINING THE REGULA-FALSI METHOD TO ACHIEVE SUPER-LINEAR CONVERGENCE

H. H. S. Ziya[1*], W. A. Gunarathna[1] and M. A. M. Mohamed[1]

[1]Department of Physical Sciences, Rajarata University of Sri Lanka Mihintale, Sri Lanka.
[*]safwahasan319@gmail.com

Developing numerical methods such as the Interval Bisection, Regula-Falsi, Secant and Newton-Raphson methods for solving nonlinear equations has been an active area of research over the years due to the limited applicability of exact root-finding techniques and their numerous applications in computational science. The Regula-Falsi method is a two-point iterative technique that is used to seek approximate roots for nonlinear equations. However, this method is linearly convergent to exact roots. In this study, a new root-finding technique has been therefore proposed to enhance the convergence order of the classical Regula-Falsi method. To construct this, a convex combination of the classical Newton-Raphson approach is employed at two distinct approximations with convex weights $\lambda_1 = \lambda$ and $\lambda_2 = 1 - \lambda$, where $0 \leq \lambda \leq 1$. The convergence analysis of this method was established, and it was found that it converges super-linearly with order $\sqrt{2}$. The iterative formula of the proposed method requires the computation of the derivative of nonlinear functions at every iteration. This poses difficulties when nonlinear functions are not explicitly known or when derivatives of nonlinear functions are challenging to calculate due to their complicated formulas. Therefore, the proposed method was further improved by replacing its derivative components with finite difference quotient approximations for first derivative. To validate the effectiveness of the proposed techniques, several numerical test examples were carried out. The test results for various values of λ were compared with those of the Bisection, Secant, and Newton methods for accuracy and efficiency. The tests demonstrate that the accuracy of the proposed methods is consistent with that of the other methods. Both the methods are more efficient than the Bisection and Regula-Falsi methods. However, the efficiency of the derivative-based method is lower than that of the Secant and Newton-Raphson methods. The derivative-free method displays a higher efficiency than the derivative-based method and is, in fact, more efficient than the Secant method. For example, when $\lambda = 0.25$ and the initial approximations: $x_0 = -0.4$, $x_1 = 0.5$ for the exact root $r = 0$ of the equation: $\sin x\, e^x + \ln(x^2 + 1) = 0$, the Secant, derivative-based , and derivative-free methods reguire 9, 10 and 7 iterations to achive approximations of 0.000000000000009, 0.0000000000014123 and 0.0000000001158347 for the root $r = 0$, respectively . Additionally, the study reveals that there are families of super-convergence root-finding techniques that exist between the Bisection and Secant methods.

Keywords: *Convergence order, Newton method, Non-linear equations, Regula-Falsi method*

AN APPROACH TO COLLECT MAXIMUM QUANTITY OF SUPPLY BY MINIMIZING TRAVELLING DISTANCE IN THE CAPACITATED VEHICLE ROUTING PROBLEM

M. C. A. Shafeer[1]*, S. R. Gnanapragasam[2] and W. A. Gunarathna[1]

[1]Department of Physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale
[2]Department of Mathematics, Faculty of Natural Sciences, The Open University of Sri Lanka, Nawala, Nugegoda
**Shafeer.caseem@gmail.com*

This research investigates the Capacitated Vehicle Routing Problem (CVRP), aiming to minimize overall travel distance while maximizing the quantity of supplies collected. The study utilizes a combination of the K-Nearest Neighbour (KNN) algorithm and two innovative heuristic methods: the Factor-Based Proposed Approach (FBPA) and the Factor-Based Approach with Capacity Consideration (FBACC). KNN serves as a simple baseline heuristic for constructing cost-effective routes. The FBPA introduces a supply-to-distance ranking system to prioritize supply nodes that offer an optimal balance between quantity and travel cost. The FBACC method further enhances performance by incorporating vehicle capacity awareness, preventing early saturation and enabling vehicles to collect more supplies before returning to the warehouse. To evaluate these methods, 35 randomly generated small-scale problem instances were created to simulate real-world supply collection scenarios, each with variations in supply demand, node placement, and vehicle capacity. Among these, 32 instances yielded feasible solutions for FBPA and 24 instances yielded feasible solutions for FBACC, providing a consistent basis for comparison. Data were carefully structured to ensure input consistency and scenario diversity. Total travel distance and quantity of supplies collected were used as the primary performance metrics. Experimental results show that FBPA consistently reduced total travel distance compared to KNN, while maintaining or improving the overall supply collection. Although the FBACC method resulted in slightly longer routes, it proved effective in handling complex constraints by promoting more balanced load distribution. These results were analysed numerically, highlighting clear performance differences and supporting the practical value of the proposed approaches. The study demonstrates an appropriate methodology in data generation, problem modelling, and performance evaluation. By balancing route efficiency with supply maximization, factor-based heuristics, especially when enhanced with capacity considerations, offer practical and effective solutions for vehicle routing in constrained supply chain environments. These contributions advance the field of logistics optimization by delivering flexible strategies suited to real-world applications.

Keywords: *Capacitated vehicle routing problem, K-Nearest Neighbour, Factor-Based approach, Logistics, Supply chain management*

CONTROL CHART APPROACH FOR PREDICTING ROUTE-WISE LOGISTIC COSTS IN CUSTOMER SATISFACTION-BASED BAKERY PRODUCT SUPPLY CHAINS

T. M. N. Silva[1*] and E. M. U. S. B Ekanayake[1]

[1]Department of Physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale.
**miyunisha@gmail.com*

Efficient logistics management is crucial for bakery product supply chains due to the perishability of the products and the need for timely delivery. Traditional logistics cost prediction models often fail to incorporate customer satisfaction factors, which are vital for long-term business success and competitive advantage. The proposed model considers key cost components such as transportation, warehousing, inventory management, regulatory compliance, and environmental sustainability. Based on financial mathematics principles, the research integrates key variables such as actual logistic costs (AC) and expected logistic costs (EC), profitability (PI), and customer satisfaction (SI). To predict route-wise logistic costs, this study initially develops Model 1. Model 1 incorporates cost variability (CV), cost performance index (CPI), profitability index (PI), and satisfaction indices (SI) to predict logistic costs under optimistic and pessimistic scenarios for 22 Routes. Model 2 refines this approach using Statistical Process Control (SPC), particularly C-chart limits (LCL, CL, UCL), to refine Model 1 and regulate customer satisfaction data across the company's process and for all 22 routes. A hybrid model combines both methodologies, leveraging their strengths to improve cost forecasting and supply chain efficiency. Data analysis was conducted using Microsoft Excel, while MATLAB was employed for model validation. The analysis compares three models: Model 1, Model 2, and a Hybrid Model based on RMSE, R^2, MAPE, and accuracy metrics. Results indicate that the Hybrid Model outperforms, both models, achieving the lowest RMSE = 11,578.33, highest R^2 = 0.9951, and best accuracy = 98.28%. However, the study acknowledges that real-world complexities, such as fluctuating demand and customer complaints, can impact cost prediction accuracy. This study presents a reliable logistic cost prediction model based on the assumption of constant demand, offering valuable insights for future decision-making in cost management and optimization within the bakery product supply chain.

Keywords: *Bakery products, Customer satisfaction, Control charts, Logistic costs, Supply chain*

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DEVELOPING EFFECTIVE OPTIMIZATION TECHNIQUES FOR TRANSPORTATION AND ASSIGNMENT CONCERNS

S. B. R. D. Dhananjalee[1*] and E. M. U. S. B. Ekanayake[1]

[1]Department of Physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
**dinushidhananjalee@gmail.com*

This research develops advanced optimization techniques for solving transportation and assignment problems, addressing key challenges in logistics and resource allocation. There are two perspectives from which this research is being considered. One is working on transportation problems (TPs) using new methods, and the other is creating a fresh strategy for assignment problems (APs). Various methods, such as the North West Corner Method (NWCM), Least Cost Method (LCM), Vogel's Approximation Method (VAM), Row Minima Method (RMM), and Column Minima Method (CMM), are designed to find an initial basic feasible solution (IBFS), while the Stepping Stone Method (SSM) and the Modified Distribution (MODI) Method refine these solutions to achieve optimality in transportation problem. Similarly, several techniques have been developed for solving assignment problems, including Maximum Difference Cost Method, New Revised Zero's to One's Method, Bottleneck Cost Method, Modified Ant Colony Optimization Algorithm, and Matrix One's Assignment Method. The Hungarian Method (HM), introduced in 1955, remains a widely used approach for obtaining precise solutions to small and medium-sized assignment problems. In this study, an enhanced Vogel's Approximation Method is proposed by incorporating row and column averages, followed by the calculation of penalty costs based on the difference between the nearest minimum and maximum values of these averages. The maximum possible allocation is then made accordingly. This modification improves both the accuracy and efficiency of solutions for balanced and unbalanced transportation problems. Additionally, a statistical approach integrating the log-normal distribution and the geometric mean (GM) is developed to address prohibited transportation problems. In this approach, the cost matrix is first converted into cumulative probabilities based on the log-normal distribution, after which the geometric mean is used to calculate the penalty costs. The maximum possible allocation is then performed while avoiding allocations on prohibited routes. Furthermore, a modified genetic algorithm (GA) is introduced for solving both balanced and unbalanced assignment problems. A binary encoding system is utilized to represent the initial population, and tournament selection based on a cost minimization fitness function is employed to select the best strings to serve as parents for the next generation. A crossover operator, designed based on penalty cost calculations, is applied to interchange genes and produce high-quality offspring, while swap mutation is used to prevent redundant assignments. The proposed methods are applied to both balanced and unbalanced cases, as well as benchmark and randomly generated assignment problems. MATLAB codes were developed to implement the proposed methods for general cases. The code was tested on several benchmark numerical examples to evaluate its performance, including the measurement of computational time.

Keywords: *Assignment problem, Genetic algorithm, Log – Normal distribution, Prohibited transportation problem, Transportation problem*

SURVIVAL ANALYSIS OF MICH HY3 CHILI SEED GERMINATION AND IDENTIFICATION OF INFLUENTIAL FACTORS

A.G.N.Widusika[1*], H.T.K.Abeysundara[2] and W.A.Gunerathne[1]

[1]*Department of Physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka.*
[2]*Department of Computer and Statistics, Faculty of Science, University of Peradeniya.*
nuwaniwidushika@gmail.com

This study investigates the germination potential of MICH HY3 chili seeds, a hybrid variety recently developed in Sri Lanka with significant export potential. The research aims to analyze the effects of treatment temperature, growth media, treatment duration, and storage conditions on seed germination, using controlled experiments and survival analysis techniques. Data from 767 observations were analyzed using Kaplan-Meier survival curves and Cox Proportional Hazards models to evaluate the influence of these factors. This study fills a knowledge gap in survival pattern of MICH HY3 chili seeds and provides actionable insights for improving germination practices. While the findings are based on controlled conditions, they have practical implications for optimizing agricultural production and storage strategies. Results indicate that temperature is critical, with an optimal range of 25–30°C maximizing germination rates and minimizing germination time. Shorter treatment durations (1 minute, 1 hour) resulted in slower germination rates, whereas longer durations (24 hours, 5 hours) achieved faster and higher germination success. Growth media with low osmotic potential and appropriate storage conditions also significantly enhanced germination outcomes. The interaction model (Correlation Coefficient= 0.97) demonstrated the synergistic effects of multiple factors, highlighting the importance of comprehensive treatment strategies. Future research should explore additional environmental variables and field-based applications to further enhance germination efficiency and seedling development.

Keywords: *Chili, Duration, Germination rate, Proportional hazard, Survival*

APPLICATION OF FIFTH AND SIXTH ORDER RUNGE-KUTTA VARIANTS TO SOLVE THE QUADRATIC RICCATI EQUATION

B. H. O. Jayasinghe[1*], W. A. Gunarathna[1] and M. A. M. Mohamed[1]

[1]Department of Physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka
**jhimanthi@gmail.com*

The quadratic Riccati equation is a nonlinear ordinary differential equation that has found significant applications across many fields, including control theory, biological sciences, stochastic processes and finance. While solving this equation with existing analytical methods, its non-linearity gives rise to formidable challenges, such as lack of closed form solutions, singularity issues, and complex solution forms. Alternatively, computational methods have been employed to obtain numerical solutions to the quadratic Riccati equation. However, existing numerical methods such as Euler, Taylor series, and Runge-Kutta methods often fail to meet the numerical accuracy demanded by most applications. For example, the forward and backward Euler methods have first-order accuracy. Taylor series methods need the computation of higher-order derivatives. Recently, the classical fourth-order Runge-Kutta method has been applied to the Riccati equation, confirming the fourth-order accuracy in its results. In this study, fifth and sixth order Runge-Kutta methods are employed to the Riccati equation. Stability and convergence of the methods are analysed. To validate their accuracy, four numerical test examples with known exact solutions were implemented in MATLAB. For various mesh sizes, the maximum absolute errors at internal mesh points were computed and compared to the corresponding results obtained using the fourth order Runge-Kutta method. The results from three of the numerical tests demonstrated that the accuracy of the proposed fifth-order method exceeds that of the fourth-order method, while one test showed that both the fifth and fourth-order methods exhibited nearly equal accuracy. However, the sixth-order method yielded lower numerical accuracy than the other two methods. Additionally, the numerical efficiency of each method was assessed by measuring the computational times executed to solve each example problem. Based on these analyses, it can be concluded that the fifth-order method is better suited for numerical computations of the quadratic Riccati equation.

Keywords: *Higher order Runge-Kutta methods, Initial value problems, Numerical solution, Riccati differential equation*

AN ENHANCED BAT ALGORITHM FOR MULTIVARIABLE UNCONSTRAINED NONLINEAR PROGRAMMING

M. M. Nawodya[1*] and M. K. D. D. Sandaruwan[1]

[1]Department of Physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale.
[*]mnawodya4@gmail.com

The Unconstrained Multivariable Nonlinear Programming (UMNLP) problem focuses on optimizing a nonlinear objective function with multiple variables in the absence of constraints. UMNLP problems are inherently complex due to their high-dimensional search spaces, numerous local optima, and nonlinearity, making them impractical to solve using traditional optimization methods. Therefore, heuristic approaches are generally employed to solve these problems. The Bat Algorithm (BA) is a prominent meta-heuristic optimization technique inspired by the echolocation behaviour of bats. It mimics the way bats search for prey using ultrasound waves. Although various modifications to the BA have been proposed in the literature to solve the UMNLP problem, those algorithms frequently encounter premature convergences. This study introduces an enhanced version of the BA, incorporating several novel modifications to overcome the limitations of the existing approaches. Key enhancements include two adaptations from prior research: the integration of an adaptive inertia weight mechanism to balance exploration and exploitation across iterations, and the application of a conjugate gradient-based local search direction to improve convergence accuracy. In addition to these adaptations, two novel mechanisms are introduced: a dynamic position updating equation, designed to effectively utilize the positional relationships between bats during the search process, and a new concept termed 'Smell-radius', which enhances local search by scaling exploratory movements based on the proximity to optimal solutions. A comprehensive comparative study was conducted to evaluate the performance of the enhanced BA against the standard BA, the Modern Computerized Bat Algorithm (W. H. Bangyal et al., 2022), and the Particle Swarm Optimization algorithm using a set of fifteen widely recognized benchmark test functions. The average deviation from the global optima and computational time were used as the primary performance measures. In addition, the evaluation considered the average and standard deviations of function values across 30 independent runs, the best (minimum) and worst (maximum) solution values, and the average and standard deviation of computational time for each algorithm on each benchmark function to assess stability and computational efficiency. Based on these comprehensive metrics, the results demonstrate that the enhanced BA consistently outperforms the three comparative algorithms, delivering superior solution accuracy, better robustness, and competitive computational efficiency.

Keywords: *Bat algorithm, Dynamic position update, Multivariable unconstrained nonlinear programming, Particle swarm optimization*

A NEW GENERALIZED MATHEMATICAL MODEL FOR INCIDENCE COLORING OF LADDER RELATED GRAPHS AND SQUARE GRID GRAPH

S.S. Nuwanthi [1*], A.A.I. Perera[2] and M.A.M. Mohamed[1]

[1]*Department of Physical Science, Faculty of Applied Sciences, Rajarata University of Sri Lanka*
[2]*Department of Mathematics, Faculty of Science, University of Peradeniya, Sri Lanka*
**nuwanthishyamika@gmail.com*

Graph theory is a fundamental area of discrete mathematics, providing powerful tools for modeling and solving complex problems across diverse fields. It is widely applied in computer science, urban planning, network optimization, and many other fields. One key research area in graph theory is graph coloring, where colors are assigned to different elements of a graph under specific constraints.

This research focuses on incidence coloring, a variation of graph coloring, that extends traditional vertex and edge coloring by assigning colors to incidences, which are pairs (v, e) consisting of a vertex v and an edge e that is incidence to v. The objective is to color incidences so that no two adjacent incidences share the same color, However, non-adjacent incidences may have the same color. The concept of incidence coloring of a graph was first introduced by Brualdi and Quinn Massey in 1993. It involves assigning colors to incidences of a graph such that adjacent incidences receive different colors. If a vertex v is one of the endpoints of an edge e, then v and e are said to be incident with each other. Two incidences (v, e) and (w, f) are said to be adjacent or neighboring if at least one of the following conditions holds: (i) $v = w$, (ii) $e = f$, (iii) the edge $vw = e$ or $vw = f$.

This study considers the incidence coloring of finite, simple, undirected graphs. A new mathematical model for the incidence coloring of ladder-related graphs and square grid graphs is developed. The methodology involves assigning numerical values to incidences, identifying patterns in these assignments, and labeling the vertices and incidences in a structured manner. Using the observed patterns and applying knowledge of arithmetic sequences, generalized equations are formulated. The model aims to minimize the total number of colors while satisfying the conditions of incidence coloring.

A mathematical model is developed for the incidence coloring of a ladder graph with any finite number of vertices using the minimum number of colors. It also investigates how the incidence chromatic number of a ladder graph changes when subdivisions are introduced and evaluates the applicability of the developed model to the subdivided ladder graph.

Furthermore, the study focuses on developing a mathematical model to perform incidence coloring on square grid graphs with any finite number of vertices while minimizing the number of colors used. This model is also adapted to handle incidence coloring of step ladder graphs. This minimum number of colors required for incidence coloring is known as the incidence chromatic number.

Keywords: *Graph coloring, Incidence coloring, Square grid graph, Ladder graph, Step ladder graph*

A DEMAND-SPLITTING HEURISTIC APPROACH FOR SOLVING THE SPLIT DELIVERY VEHICLE ROUTING PROBLEM

S.J.K. Rajitha[1*] and M.K.D.D. Sandaruwan [1]

[1]Department of Physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale.
[*]krishansalk@gmail.com

The Split Delivery Vehicle Routing Problem (SDVRP) is one of the challenging variants of the Capacitated Vehicle Routing Problem (CVRP), where customer demands can be met through multiple deliveries rather than a single visit. This flexibility makes the SDVRP more cost effective in real-world logistics but significantly increases complexity. Exact solution methods are computationally expensive and difficult to implement for large scale problems. As an alternative, heuristic or meta-heuristic approaches are used to get near optimal solutions. A priori demand splitting strategies, such as the Priori Splitting Algorithm (PSA) and the Priori Adaptive Splitting Algorithm (PASA), restructure SDVRP instances into CVRPs, allowing them to be solved using CVRP meta-heuristic algorithms. This study evaluates the effectiveness of the PSA and the PASA in combination with three CVRP meta-heuristic algorithms: Google OR-Tools (GO), Ant Colony Optimization (ACO), and Particle Swarm Optimization (PSO). A comparative study was conducted to test the performance of all six combined algorithms: PSA-GO, PASA-GO, PSA-ACO, PASA-ACO, PSA-PSO, and PASA PSO, using 25 well-known benchmark SDVRP instances and presented the most effective combination. And also it is compared with previous existing approaches. Results indicate that GO based algorithms consistently produced the most efficient routes, outperforming other approaches in both solution quality and computational efficiency. ACO based algorithms exhibited longer computational times, while PSO based algorithms yielded the weakest solutions. Further analysis revealed that PASA-GO achieved the lowest average deviation from the best-known solutions, making it the most effective combined algorithm when prioritizing solution quality. These findings confirm that a priori demand-splitting strategies, particularly PASA, effectively transform the SDVRPs into the CVRPs while maintaining high-quality solutions. The study concludes that GO-based algorithms provide the best trade-off between solution accuracy and computational efficiency, making them the most promising approach for solving large-scale SDVRPs. To assist real-world practitioners, a mobile application was developed to solve SDVRPs using PASA-GO, which has been identified as the most effective algorithm. This application enables users to input practical SDVRP instances via an interactive map. It then generates optimal delivery routes and visualizes the solution on the map, enhancing user-friendliness and practicality.

Keywords: *Split delivery vehicle routing problem, Capacitated vehicle routing problem, Google OR-Tools, Ant colony optimization, Particle swarm optimization*

AN APPROACH TO SOLVE THE SYMMETRIC TRAVELING SALESMAN PROBLEM USING HEURISTICS THAT USE ANT COLONIES, GENETIC ALGORITHMS, AND THE ARITHMETIC MEAN

S.M.T. Ruwan [1*] and E.M.U.S.B. Ekanayake[1]

[1]Department of physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka
** tharakaruwan420@gmail.com*

The Traveling Salesman Problem (TSP) is a classic combinatorial optimization challenge that aims to determine the most efficient route for a salesman to visit a set of cities exactly once and return to the point of origin. This problem has significant real-world applications in logistics, supply chain management, transportation routing, and network optimization. While exact algorithms such as Branch and Bound and Dynamic Programming guarantee an optimal solution, they become computationally impractical as the number of cities increases due to the exponential growth in complexity (NP-hard nature of TSP). Genetic Algorithms (GA), Simulated Annealing (SA), and Ant Colony Optimization (ACO) have been widely used to obtain near-optimal solutions within a reasonable time frame. However, these methods often require an excessive number of iterations to refine their solutions effectively. Also, Approaches like Genetic Algorithms and Simulated Annealing can often get stuck in suboptimal local minima, leading to solutions that are far from the global optimum and Algorithms such as ACO heavily depend on parameters like pheromone evaporation rates, learning coefficients, and heuristic factors, requiring careful tuning for effective performance. To address these challenges, this research introduces an enhanced hybrid optimization framework that incorporates a structured edge classification strategy based on the arithmetic mean of the distance matrix. This approach systematically categorizes edges into four groups: necessary, primary, secondary, and unnecessary, allowing the algorithm to prioritize the most promising connections and discard less relevant paths. By intelligently narrowing the search space, the computational burden is significantly reduced without compromising solution quality. The proposed methodology begins by reversed technique of Ant Colony Optimization (ACO) to construct an initial near-optimal tour by mimicking the pheromone-based pathfinding behaviour observed in ant colonies. This phase effectively explores the solution space and establishes a strong foundation. Next, a Genetic Algorithm (GA) is applied to fine-tune the solution by employing mutation operator to further refine the route and minimize travel distance/cost. The integration of these two powerful heuristics enhances solution accuracy and accelerates convergence. Through extensive computational experiments, the proposed approach demonstrates a substantial reduction in iteration count and computational time while maintaining high solution accuracy. Compared to conventional heuristic techniques, it consistently delivers more efficient and scalable solutions for large-scale TSP instances. This novel hybrid strategy not only improves the precision and efficiency of TSP solvers but also paves the way for future advancements in route optimization, vehicle scheduling, and network design applications.

Keywords: *Symmetric traveling salesman problem, Arithmetic mean, Ant colony optimization, Genetic algorithm, Hybrid optimization*

TRIANGLE-BASED GRAPHS USING SUPER EDGE-MAGIC TOTAL LABELING FOR CRYPTOGRAPHIC APPLICATIONS AND CORDIAL LABELING

G.L.N. Sandarekha[1]*, A.A.I. Perera[2] and M.A.M. Mohamed[1]

[1]Department of Physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka
[2]Department of Mathematics, Faculty of Sciences, University of Peradeniy, Peradeniya, Sri Lanka
[*]asp2019060@as.rjt.ac.lk

Graph theory, a fundamental branch of mathematics, analyzes the structural properties of networks formed by vertices and edges. Graph labeling is a one of the powerful that provides valuable insights into combinatorial and structural properties with significant theoretical and practical applications. Different labeling techniques, such as radio labeling, harmonious labeling, graceful labeling, and magic labeling, have been extensively studied. This research specifically focuses on cordial labeling for the triangle tail graph and super edge magic total labeling (SEMTL) for the triangle snake graph, introducing novel labeling patterns that enhance both theoretical knowledge and real-world applications. The study establishes that the triangle tail graph adheres to cordial labeling rules, ensuring a balanced distribution of vertex and edge labels. Additionally, it proves that the triangle snake graph satisfies super edge-magic total labeling by assigning a unique magic sum to each labeled edge-vertex combination. These findings contribute to the expansion of graph labeling research by extending these labeling methods to previously unstudied graph structures. Beyond theoretical contributions, this research integrates super edge-magic total labeling into cryptographic applications. A novel encryption and decryption algorithms are proposed, leveraging the structure of the triangle snake graph to improve data security. A Python-based implementation was developed to encode English alphabetic characters, with planned extensions for alphanumeric encryption. The study demonstrates how combinatorial labeling techniques can enhance cryptographic systems by providing a structured and efficient encoding mechanism.

This research bridges the gap between abstract graph labeling theories and applications, particularly in secure communication systems. This study lays a foundational framework for future research in graph theory and network security. Future directions will include extending these findings to other graph families and further refining cryptographic models based on labeled graphs.

Keywords: *Super edge magic total labeling, Cordial labeling, Cryptography, Encryption, Decryption*

PHYSICS

SYNTHESIS, CHARACTERIZATION, AND PERFORMANCE EVALUATION OF SUPERCAPACITORS USING KEROSENE OIL-DERIVED CARBON SOOT AS AN ELECTRODE MATERIAL

E.M.K.K. Aberathne[1*], P.U. Sandunika[2], H.O. Wijewardane[1], M.A.K.L. Dissanayake[2], J.M.K.W. Kumari[2]

1 Department of Physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka
2 National Institute of Fundamental Studies, Hanthana Road, Kandy, Sri Lanka
[*]keshanikka@gmail.com

Energy storage technologies have gained significant attention in recent years due to the increasing demand for sustainable and efficient power sources. Among various energy storage devices, supercapacitors have emerged as a promising alternative to conventional batteries due to their high power density, rapid charge-discharge capability, and long cycle life. Supercapacitors are typically constructed using two electrodes, an electrolyte, and a separator. This study mainly focuses on investigating and enhancing the performance of kerosene oil-derived carbon soot as an electrode material for supercapacitors. In particular, the study aims to identify the optimum sintering temperature, determine the best binder, and evaluate the performance improvements when a conducting polymer is integrated with the carbon soot-based electrode. In this study, an electric double-layer capacitor (EDLC) was assembled with electrodes that were prepared using kerosene oil-derived carbon soot and 0.5M KOH as an electrolyte. Ethanol was used as a solvent for the preparation of electrode material and the Doctor-blade method was used to deposit electrode material on fluorine-doped tin oxide (FTO) glasses. Supercapacitor characterization was done using Electrochemical Impedance Spectroscopy (EIS), Cyclic Voltammetry technique (CV), and continuous Galvanostatic charge-discharge (GCD) tests. Material characterization was done by using Raman Spectroscopy, Scanning Electron Microscopy (SEM), and X-ray Diffraction (XRD). To identify the optimum sintering temperature, electrodes were thermally treated at 50 °C, 100 °C, 200 °C, and 300 °C. CV data were used to calculate the specific capacitance values. Among the tested temperatures, the electrode sintered at 100 °C exhibited the highest specific capacitance. Then, the effect of different binders on electrode performance was evaluated at 100 °C using CV. The tested binders included Triton X-100, polyvinylpyrrolidone (PVP), carboxymethylcellulose (CMC), and polyethylene glycol (PEG). Among these, Triton X-100 demonstrated the best performance, achieving a maximum specific capacitance of 0.3 F g^{-1} at 0.01 V s^{-1} scan rate. Subsequently, a series of composite electrodes were prepared using kerosene-oil-derived carbon soot and polyaniline (PANI) in varying ratios (C soot (mg): PANI (mg) = 0:50, 10:40, 20:30, 30:20, 40:10, 50:0) to evaluate their effect on capacitance. Triton X-100 was used as the binder, and all samples were processed at 100 °C. Among the tested compositions, the 20:30 (carbon soot : PANI) composite exhibited the highest specific capacitance of 1.00 F g^{-1} at 0.01 V s^{-1} scan rate. Galvanostatic charge-discharge measurements were conducted to evaluate the performance of supercapacitors using electrodes made from pure kerosene-oil-derived carbon soot, pure polyaniline (PANI), and the optimized 20:30 (carbon soot : PANI) composite. These findings highlight the potential of the kerosene oil-derived carbon soot as an electrode material for effective use in energy storage applications.

Keywords: *Supercapacitors, Electric Double-layer Capacitor, Specific Capacitance, Carbon Soot, Polyaniline, Nanocomposites*

Acknowledgments: The authors thank the National Institute of Fundamental Studies, Kandy, and Professor T.M.W.J. Bandara, University of Peradeniya, for providing valuable resources and facilities that supported this research.

INTEGRATED GEOPHYSICAL AND GEOCHEMICAL ANALYSIS OF WAHAWA GEOTHERMAL FIELD TO UNDERSTAND THE CHARACTERISTICS OF THE HEAT SOURCE

D. J. Jeewanika[1*], S.A. Samaranayake [1], A.M.C. Herath[2] and C.A. Thotawatthage[1]

1Department of Physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
[2]Department of Chemical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
**jeyjeew10@gmail.com*

In Sri Lanka, mainly the power is generated from non-renewable energy sources. It is essential to meet the country's energy demand by developing and adopting renewable sources. This study focuses on assessing the geothermal potential of Wahawa geothermal field through integrated geophysical and geochemical methods. Geochemical characterization is done using in-situ measurements, pH, electrical conductivity, and wellhead temperatures as well as major anion and cation concentrations were determined through laboratory assessments. Based on the chemistry of water samples from 12 locations of the field, the chemical geothermometric calculations estimate the maximum reservoir temperature to be 186°C. The gravity, magnetic and resistivity data obtained from the geophysical measurements are used in determining the geometry and the location of the heat source. According to the 2D resistivity profiles obtained, the pathway of the fracture zones in the field are roughly estimated and the results revealed the presence of a high electrical conductive zone beneath the field area. The fractures identified via resistivity imaging are plunging towards the dolerite dyke suggesting that the potential reservoir is beneath the dyke. Gravity and magnetic results collectively supports the presence of a geothermal reservoir associated with the dolerite dyke intrusions, which was supported by the literature. The results revealed that, the hot springs from the geothermal field are located on a hard metamorphic rock terrain and the geothermal reservoir is possibly located beneath the dolerite dyke intrusion which is aligned towards the northwest of the hot spring system. To assess the energy generation capacity of the field, a Monte Carlo volumetric assessment was conducted using parameters such as surface area, reservoir thickness, temperature distribution, and porosity. The volumetric assessment predicts with a 90% probability that the reservoir could produce 2.60 MWe for 30 years.

Keywords: *Geothermal energy, Low-enthalpy system, Geothermometry, Monte-Carlo volumetric assessment, Resistivity profiling*

Acknowledgements: Authors are grateful to Prof. Meththika Vithanage, Faculty of Applied Sciences, University of Sri Jayewardenepura Sri Lanka for chemical analysis.

INVESTIGATION OF PERFORMANCE OF Mn - N CO-DOPED TiO_2 PHOTOELECTRODES FOR DYE-SENSITIZED SOLAR CELLS

W. H. H. Silva[1*], C. A. Thotawatthage [1] and T. Jaseetharan[2]

[1]Department of Physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka
[2]Department of Physical Sciences, Faculty of Applied Sciences, South Eastern University of Sri Lanka
[*]harithahimasha9851@gmail.com

Usually, P25 Titanium dioxide (TiO_2) nanoparticles are used to fabricate dye-sensitized solar cells (DSSCs). In this study, P25 TiO_2 was co-doped with Manganese (Mn) and Nitrogen (N) and DSSCs were fabricated and characterized. In order to investigate the performance of the co-doped electrodes, DSSCs were fabricated with N doped TiO_2, Mn doped TiO_2, and un-doped TiO_2 electrodes. In literature, additionally to NH_4OH, a continuous flow of N_2 gas has been used to synthesize N-doped TiO_2. However, in this experiment, a continuous flow of N_2 gas was not used. The doctor blade method was used to deposit the thin film layers on Fluorine-doped tin oxide (FTO) glasses and then subjected to thermal treatment. A 0.3 mM solution of N719 dye was used to sensitize the photoanodes. The DSSCs were fabricated by assembling synthesized photoanodes with a Platinum (Pt) counter electrode. An appropriate amount of I^-/I_3^- electrolyte was injected in between the dye-coated photoanode and Pt counter electrode for all individual cells. Material characterizations for Mn-N co-doped TiO_2, Mn doped TiO_2, N doped TiO_2, and un-doped TiO_2 were conducted by X – ray Diffraction Spectroscopy (XRD). Fabricated DSSCs were investigated by current density-voltage (J-V) characterization, and Electrochemical Impedance Spectroscopic (EIS) measurements. DSSCs with Mn-N co-doped TiO_2 obtained an overall power conversion efficiency of 0.03% .The other DSSCs with un-doped TiO_2, N-doped TiO_2, Mn-doped TiO_2 showed only 2.93%, 4.16%, and 0.01% power conversion efficiencies, respectively. All results were obtained under stimulated illumination (100 $mWcm^{-2}$, 1 sun) with AM 1.5 filter. According to the results, N-doped TiO_2 shows highest efficiency among other solar cells. According to the literature, N-doped and Mn-doped DSSCs show higher efficiencies (6.06% and 4.87% respectively) compared to the un-doped TiO_2 DSSCs. The amount of doped materials, the method used to dope materials, thickness of the photoanode, the crystal size and the phase of the materials and the reaction between materials during the doping process are the major factors that determine the success of fabricated solar cells. However, the results obtained in this study show there is no efficiency enhancement of DSSCs that were incorporated with co-doped Mn and N. It does not show the increased photocurrent generation in the photoanode. The results obtained from the EIS confirmed no efficiency enhancement of the photoanodes with Mn-N co-doped TiO_2, and Mn-doped TiO_2 also did not show efficiency enhancement. Further investigation should be implemented to find the errors and to obtain desired results.

Keywords: *P25 Titanium dioxide, Doctor blade, Photoanodes, Spectroscopy, Illumination*

Acknowledgements: Authors are grateful to Mr. Saranga Sanathchandra and the Physics laboratory staff of the Faculty of Applied Sciences, Rajarata University of Sri Lanka, for providing the necessary equipment and technical support and Professor T.M.W.J. Bandara, Department of Physics, Faculty of Science, University of Peradeniya, Peradeniya for I-V measurements and electrochemical impedance analysis.

SYNTHESIS, OPTIMIZATION AND CHARACTERIZATION OF MUSHROOM (*Pleurotus ostreatus*) STEMS DERIVED CHITOSAN BASED GEL POLYMER ELECTROLYTES FOR MAGNESIUM ION BATTERY APPLICATION

H.N. Anuththara[1*], G.K.G.A. Karunarathne[2], G.G.S. Sewwandi [2], C.A. Thotawatthage[1], M.A.K.L. Dissanayake[2] and J.M.K.W. Kumari[2]

[1]Department of Physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka
[2]National Institute of Fundamental Studies, Hantana road, Kandy, Sri Lanka.
**anuththara981@gmail.com*

Energy storage devices like batteries rely on electrolytes to transport ions between electrodes, enabling electrochemical reactions. Traditional liquid electrolytes have great high ionic conductivity but present safety concerns such as leakage, flammability, and chemical reactivity. Solid electrolytes improve safety and stability but are limited by their low conductivity at room temperature and mechanical brittleness. Gel polymer electrolytes (GPEs) combine the advantages of both by providing high ionic conductivity while also improving mechanical and thermal stability, making them a promising alternative for next-generation, safer, and more sustainable battery technologies. GPEs based on synthetic polymers are widely utilized in energy storage applications such as batteries. However, they pose significant environmental concerns due to their non-biodegradability (because they are petroleum-based polymers), high production costs, and potential toxicity. To address these challenges, biopolymer derived electrolytes have gained interest as sustainable alternatives. Among various biopolymers, chitosan is well known for its natural abundance, film-forming ability, and potential as a polymer host in GPEs. Commercially, chitosan is primarily extracted from crustacean shells, making it cost-effective but raises environmental concerns related to seafood waste disposal and the use of harsh chemicals in the extraction process. As an alternative this study explores the extraction of chitosan from *Pleurotus ostreatus* (oyster mushroom) stems, a renewable and plant-based source. Demineralization and deproteination were used to extract chitin, followed by deacetylation of the extracted chitin to yield chitosan. The extracted chitosan was characterized using FTIR spectra, which showed characteristic peaks at 1635 cm^{-1} (amide) and 3269 cm^{-1} (hydroxyl). The extracted mushroom stems derived chitosan was used to develop an eco-friendly GPE. Chitosan was dissolved in acetic acid along with magnesium triflate (MgTf) salt to form the polymer electrolyte matrix. A series of GPEs were prepared by varying the concentrations of MgTf (chitosan: MgTf 10,15, 20, 25, 30, and 40 wt%). The highest ionic conductivity of 2.3×10^{-4} S/cm was achieved at 25 wt% MgTf. The optimized chitosan MgTf electrolyte was further enhanced with titanium dioxide (TiO_2) nanofillers with different amounts (chitosan: TiO_2 2, 4, 6, 8 wt%). To further improve the mechanical properties of the electrolyte, Titanium dioxide nanoparticles (TiO_2) were added to the optimized system as a nanofiller. The ionic conductivity of the electrolyte was improved as 3.79×10^{-4} S/cm for 6 wt% TiO_2 added system. The synthesized GPEs were characterized using Fourier-transform infrared spectroscopy (FTIR) to analyze polymer-salt interactions, Electrochemical Impedance Spectroscopy (EIS) to evaluate ionic conductivity measurements, and DC polarization measurement to calculate the electronic transference numbers.

Keywords: *Gel polymer electrolytes, Chitosan, Magnesium triflate, Ionic conductivity*

Acknowledgments: Authors are grateful to Professor T.M.W.J Bandara, Department of Physics, Faculty of Science, University of Peradeniya, Peradeniya for electrochemical impedance analysis.

DEVELOPMENT OF A SUPERCAPACITOR UTILIZING NATURAL RUBBER-BASED ELECTROLYTE AND ACTIVATED NANO CARBON ELECTRODES DERIVED FROM BAMBOO CULMS

S.H.D. Senavirathna[1*], C.A. Thotawaththage[1], H.W.M.A.C. Wijayasinghe[2], T.M.W.J. Bandara[3] and S.M.M.U. Sivirathna[2]

[1]Department of Physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
[2] National Center for Advanced Battery Research, National Institute of Fundamental Studies, Kandy, Sri Lanka.
[3] Department of physics, Faculty of science, University of Peradeniya, Peradeniya, Sri Lanka.
**dilshansenavirathna6987@gmail.com*

Super capacitors are one of the chief electricity storage applications in various industries. This study aims to produce a supercapacitor that is an environmentally friendly replacement for traditional supercapacitors with the development of renewable and biodegradable material. The electrolyte was synthesized by dissolving natural rubber carbon in tetrahydrofuran (THF), adding Lithium perchlorate ($LiClO_4$) as the conducting salt, and adding Ethylene carbonate (EC) and Propylene carbonate (PC) plasticizers that allow for better ion mobility and flexibility. FTIR suggested a successful salt-polymer interaction with the shifts in characterization peaks confirming complexation with Li^+ ions and the rubber matrix. Electrodes were produced from bamboo culms-derived nano carbon which underwent NaOH treatment to activate the surface. The XRD patterns showed semi-crystalline structure with, some graphitization, while Raman spectroscopy analysis indicated a high intensity of the D/G band, suggesting a high density of available active sites for charge storage. FTIR spectra of the carbon indicate surface functional groups to allow for better wettability and electrochemical performance.
The cell was assembled through the use of these electrodes and the gel electrolyte. Cyclic voltammetry (CV) generated rectangular curves associated with excellent capacitive behaviours and the optimum specific capacitance achieved was 180.8 F/g at 10 mV/s. The galvanostatic charge-discharge (GCD) curves were triangular and symmetry was also observed which gave a specific capacitance of 17.49 F/g at 0.81 mA/g pointing to performance limitations under higher current conditions. The electrochemical impedance spectroscopy (EIS) gave a high series resistance of 719.37 Ω which resulted in a very low ionic conductivity. However, the ionic conductivity of the gel polymer electrolyte was measured at 8.57×10^{-4} S/cm, which falls within the acceptable range for polymer-based systems and supports moderate ion transport. Despite the high internal resistance, the overall results demonstrate the potential of using biodegradable and low-cost materials in supercapacitor applications. Future work will focus on optimizing the electrolyte composition and introducing pseudocapacitive materials such as Polyaniline (PANI) to improve conductivity and enhance energy storage performance.

Keywords: *Natural rubber-based electrolyte, Activated nano carbon, Bamboo-derived carbon, Sustainable energy storage, Cyclic voltammetry*

SPIN-COATED THIN-FILM NANOCOMPOSITE MEMBRANES WITH MULTI-WALLED CARBON NANOTUBES FOR ENHANCED WATER DESALINATION AT REDUCED PRESSURE FLUX

S.D.S.E. Jayathissa[1,2*], B.V.N. Sewwandi[2], U. Dahanayake[1] and R. Weerasooriya[2]

[1]Department of Physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka
[2]National Centre for Water Quality Research, National Institute of Fundamental Studies, Hantana Road, Kandy, Sri Lanka
[*]sejayathissa@gmail.com

Pressure-driven membranes are widely used for water desalination, but their reliance on high-pressure flux poses significant energy and operational challenges. As a result, the development of energy-efficient membranes has become a key area of research. Thin-film nanocomposite (TFN) membranes, which incorporate multiwalled carbon nanotubes (MWCNTs) into the polyamide (PA) selective layer via interfacial polymerization (IP), exhibit improved structural integrity, water permeability, and contaminant rejection compared to conventional thin-film composite (TFC) membranes. However, conventional IP techniques offer limited control over the uniformity and morphology of the PA layer. This study introduces a novel fabrication approach that integrates spin coating with the IP process to produce TFN membranes. By applying varying spin accelerations, the centrifugal force helps regulate membrane formation at the nanoscale. A polyether sulfone (PES) substrate was used to support the formation of an ultrathin PA layer, synthesized through the reaction between m-phenylenediamine (MPD) and trimesoyl chloride (TMC). Spin acceleration assisted in uniformly removing excess amine solution, resulting in a defect-free and thinner PA layer. These membranes exhibited water flux values ranging from 11.16±0.56 to 18.41±0.92 L/m^2 h, with the highest flux at 60 rpm/s but lower salt rejection. Higher water flux is often associated with larger pores in the selective layer, which can compromise the salt rejection. As a result, these membranes exhibited relatively low salt rejection and water flux stability. Higher spin rates altered porosity and thickness of the PA layer, affecting both flux and salt rejection. Salt rejection was evaluated using Na_2SO_4, $MgSO_4$, $MgCl_2$, and NaCl. Membranes spun at 40 and 80 rpm/s demonstrated better salt rejection, indicating improved PA layer formation. At 40 rpm/s and 0.004% MWCNT loading, the membrane achieved over 61.36±3.07% rejection for $MgSO_4$ and 59.15±2.96% for Na_2SO_4 with a water flux of 14.45±0.72 L/m^2 h at 600 kPa. Iron nanoparticles present in the MWCNTs, synthesized via the floating catalyst method, may obstruct nanotube pores, reducing overall performance. Ongoing work focuses on nanoparticle removal and surface functionalization to further enhance membrane efficiency.

Keywords: *Desalination, Carbon nanotubes, Interfacial polymerization, Nanocomposite, Spin coating method*

GROUND MAGNETIC STUDIES OF DOLERITE DYKE IN SRI LANKA IN RELATION TO GONDWANA BREAKUP

R.A.S. Wasundara[1]*, S.A. Samaranayake [1] and U. Dahanayake [1]

[1]Department of Physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.
ranaweerawasun@gmail.com

Sri Lanka may hold the key in Gondwana reconstruction with consideration of its unique geographical position at the Gondwana break-up framework. Magnetic intrusions, particularly mafic dykes extending for long distances, are considered as one of the geological-markers of the geological history that depicts the Geo-tectonic evolution of related landmasses. Dykes of Gondwana fragments have been extensively studied in Gondwana reconstruction efforts and Sri Lankan dykes are magnetically mapped in the present study. High magnetic susceptibility values (average 40) were recorded for dolerite dykes, while the country rocks, dominantly garnet-biotite gneiss rocks, record susceptibility values below 15. Magnetic anomalies over the dykes shows strong remnant magnetic component. The similar magnetic characters for different dykes suggest that the dolerite dykes in Sri Lanka were formed simultaneously and/or under same geomagnetic field vector. Magnetic anomaly of the dolerite dykes in Sri Lanka does not equate with a mathematical model built for the present-day geomagnetic pole orientation. This suggests that the dykes were formed while the landmass of Sri Lanka was at a different orientation. Based on the modelling it was suggested that the dolerite dykes in Sri Lanka originated when the island was positioned at a latitude of 50° S. By rotation and sliding of landmass, an ideal match between raw data and the numerical model was acquired with around 155^0 clockwise rotation with respect to the present position. According to existing literature, the common thought is that when Sri Lanka and India separated from the Antarctic continent and moved into the Northern Hemisphere, Sri Lanka was attached to the southern tip of India, throughout its course to the present position. Conventionally Sri Lanka is considered to be at the southern tip of India throughout its journey from Gondwana break-up to present stage. However, the findings of this study suggest that Sri Lanka was attached to eastern cost of India as of the magnetic characters. Furthermore, our data, which indicate that Sri Lanka was rotated relative to the current north-south axis, supports the speculation that Sri Lanka was more likely connected to the middle part of India rather than its southern tip.

Keywords: *Dolerite dykes, Remnant magnetic properties, Ground magnetic studies, Anomalies, Gondwana reconstruction*

THREE-DIMENSIONAL GRAVITY MODEL FOR 85°E RIDGE BY USING SATELLITE GRAVITY DATA

K.M.S.P. Bandara[1]*, S.A. Samaranayake[1] and H.O. Wijewardane[1]

[1]Department of Physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale
**pahasaranibandara18@gmail.com*

The 85°E Ridge, a buried aseismic linear feature in the Bay of Bengal, is one of the most unique submarine geological formations of the world. Gravity measurements highlight a contrast along the ridge, with the northern portion exhibiting negative anomalies and the southern segment showing positive anomalies. Several hypotheses have been proposed for the origin of the 85°E Ridge, including its formation due to hotspot activity, magmatic processes with plume-ridge interaction and tectonic reactivation. Despite these numerous hypotheses, the precise mechanism behind the formation of the 85°E Ridge remains unresolved. Lack of attempts to build a three-dimensional model focusing specifically the 85°E Ridge, remain as a drawback in making conclusions. Most of existing studies have primarily relied on two-dimensional interpretations. The present study contributes to new insights into ridge formation through satellite-derived data with seismic constraints to create a three-dimensional gravity model for the 85°E Ridge, incorporating the laterally varying nature of the sedimentary layer through a quadratic variation approach and isostatic equilibrium of the ridge. The gravity effect due to bathymetry, oceanic crust, and upper mantle was reduced from satellite gravity data. The gravity due to mass of sediments was modelled in three dimensions using forward and inverse modelling approaches, leading to the construction of a three-dimensional sediment thickness model. To evaluate the reliability of the developed three-dimensional model, a set of control data points was extracted from existing seismic profiles across the 85°E Ridge region. These points were used to test the performance of the model, resulting in a root-mean-square (RMS) value of 0.741, which indicated a reasonable agreement between observed and modelled gravity results. An additional seismic profile, which was excluded in the modelling process, was considered for the validation process. The model successfully created the key structural and sedimentary features observed in this independent dataset, further confirming its validity and predictive capability.

Keywords: *85°E Ridge, Forward modelling, Inverse modelling, Gravity anomaly, Satellite gravity data, Seismic constraints*

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