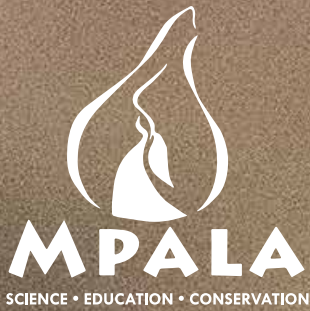




Science & Outreach 2021



Science • Education • Conservation



Cover Photo: Pied Kingfisher hovering over the Ewaso Nyiro River, Photo by Gonzalo Giribet
Inside Cover: Elephant Dreaming at Mpala, Photo by Clement Mwangi

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Clement Mwangi

Sharing The Joy & Wonder...

Dear Mpala Friends and Family,

The energy and excitement at Mpala the past few months has been inspiring to all of us here on our remote campus in Laikipia North.

It has been wonderful to watch scientists and students return and re-engage in exploration and discovery.

These have been trying times for so many both in this part of the world and in both the near and far places that our students, scientists and fellows come from. One of the things that has kept us motivated and inspired here in the field has been the fact that we have managed to sustain our operations through the on-going pandemic.

We have not just survived but thrived this past year. Continuing and new projects, grants, fellows and research questions are growing, sharing and engaging in basic and applied science.

And we are especially grateful for the additional support that has been provided by our Trustees in ensuring that core operations are sustained fully. Most of all, we are immensely thankful for each other: the team at Mpala have shown incredible care and commitment. From ensuring everyone stays healthy and safe to being wise stewards of the land, livestock and wildlife. To ensuring that we support and share what we can with those in need around us.

This year's tally of scientific papers showcases a growing breadth, depth and diversity of scholarship and knowledge. Mpala scientists are making important ground-breaking contributions to fundamental knowledge. We are growing from our core strengths of Animal Behaviour, Savannah Ecology, to include Sustainable Development, Water and One Health. I am especially pleased that for the first time in Mpala's illustrious scientific history that > 60 % of our papers have Kenyan/African authorship.

There are many challenges out there that we need to face. While 2020 was one of our wettest years on record in Northern Kenya, this year is turning out to be one of the driest. The prolonged drought has been immensely challenging for a landscape where life is so closely linked to the land, the grasses and other plants.

As I write this, I know that we can continue to sustain and survive thanks to the wise investments we made in harvesting and storing precious rainwater. We are currently using water from rains that blessed us in late 2020. And it was your incredible support and generosity that made this happen.

We look forward to welcoming you back to Mpala soon...

Dino J. Martins





About Mpala

The Mpala Research Centre was established in November 1994 at the core of the Ewaso Ecosystem, a large, geographically diverse region of central Kenya, defined by the Ewaso Ng'iro River and its tributaries. The region is part of Kenya's 80% land that is arid and semi-arid. It's characterised by savannas and woodlands, home to an estimated 550 bird species and 100 mammal species. This includes, large populations of elephants and rare species like the Grevy's Zebra, reticulated giraffe, African wild dog and black rhino. The region is unique in that little of it is formally protected yet, wildlife abundance rivals the renowned Maasai Mara and Serengeti ecosystems. The Mpala property is located on the Laikipia Plateau and covers 48,000 acres of land. The land provides a hub for experimental and manipulative research open to scientists and students. Mpala provides a 'living laboratory' without the restrictions of a national park.

This allows scientists to manipulate the environment and conduct landscape-level controlled experiments, to explore basic science, address real-world problems, and ensure that sustainable livelihoods and economic advancement are synonymous with wildlife conservation.

Mpala's Institutional Mission, is to support research that improves ecosystem functions, conserves biodiversity, and enhances the livelihoods of employees and their families who are predominantly traditional pastoralists. In conjunction with this mission, Mpala works to advance the understanding and conservation of natural and human-occupied ecosystems. This is through basic research, education, outreach, creating new scientific knowledge and developing science-based solutions to guide conservation actions for the benefit of nature and human welfare.

MPALA'S MISSION

Operate an enduring facility for research and education in environmental, biological and conservation sciences at local, national, and international levels.

Sustain a long-term environmental monitoring program, to measure changes in climate, land use, vegetation, livestock and wildlife numbers. To enable the understanding of biotic processes at the landscape level, and to identify mechanisms for maintaining the integrity of the expansive savanna ecosystem.

Develop an informed approach to conserving the natural resources of the greater Ewaso ecosystem and, lead as an example, for other 'non-protected' areas of Kenya.

Promote human and wildlife co-existence in the greater Ewaso ecosystem and provide information to help resolve conflicts.

Provide educational opportunities via experiential learning in research and monitoring skills for students and professionals from Kenya and around the world.



Partners

Mpala is a Trust of the Mpala Wildlife Foundation, Princeton University, the Smithsonian Institution, the Kenya Wildlife Service, and the National Museums of Kenya. Mpala hosts interdisciplinary research and training programs in ecology, evolution, geology, and resource management to scientists from Kenya and around the world. Researchers representing all our partners, are drawn to Mpala to study our remarkable ecosystems, making Mpala a hub for collaborative research.

In 1989 George Small created the Mpala Wildlife Foundation to fund the activities necessary to achieve his vision. The foundation supports the wildlife conservancy, a primary school for employees' children, community outreach, a Mobile Clinic and a livestock ranch that successfully coexists with an abundance of wildlife.



Princeton University serves as the managing partner for Mpala. Through Princeton University, Mpala has been awarded several NSF grants to improve facilities and rebuild the campsite. Most recently, NSF funded the construction of a cutting-edge genomics and stable isotope laboratory. Throughout the year, Princeton faculty members, researchers, graduate and undergraduate students visit the research facility to undertake research and expand their knowledge of the savannah landscape.



The Smithsonian Institution is a Trust Instrumentality of the United States, administering several Museums and Research Centers. Mpala is the Smithsonian Institution's first, permanent research facility in Africa. The Smithsonian Institution offers multiple fellowship opportunities with Mpala to promote the study of biology, anthropology, geology, hydrology, material science, social science, soil science, and related areas. The Smithsonian also collaborates with Mpala, on long-term research and monitoring on the greater Ewaso ecosystem.



The Kenya Wildlife Service is the government agency tasked to protect and manage the fauna, flora, and ecosystems of Kenya. KWS undertakes and coordinates biodiversity research and monitoring. We have research projects that collaborate with the KWS especially when collaring wildlife. More recently, the Smithsonian-Mpala Veterinary Fellow has been working with KWS veterinarians to treat injured and sick wildlife on Mpala and surrounding conservancies.



The National Museums of Kenya is a state organization that manages museums, sites, and monuments in Kenya. The NMK carries out heritage research and has expertise in subjects ranging from paleontology, ethnography, biodiversity research and conservation. A number of our researchers are affiliated with NMK and collaborate with NMK scientists, use their facilities, equipment and expertise.



Philippe Cohen

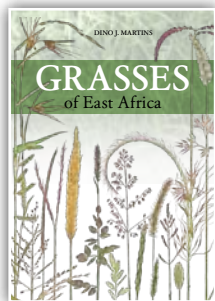
Strategic planning and Mpala team in July 2021

*Front row from left: Stacy McNulty, Beatrice Wanjohi, David Kimiti, Nelly Palmeris, Sheila Njoroge, Gikenye Chege, Philippe Cohen.
Back row from left: Dr. Dino J. Martins, Brian Kloeppe, Paul Foster, Thomas Koitmet, Zachary Ngure, John Githae, Simon Ndirangu.*



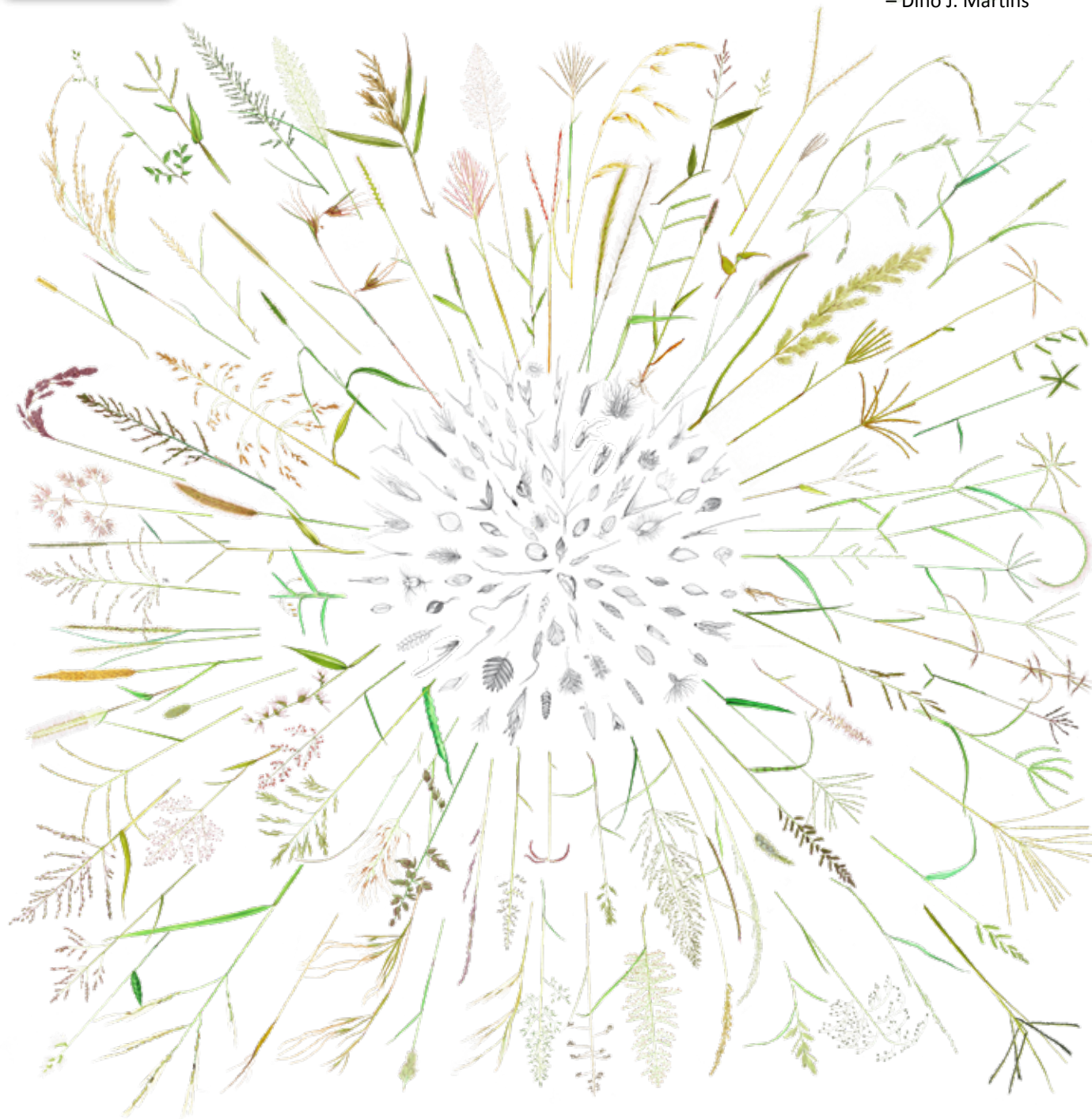


Celebrating The Wonder of Grasses



One of my lifelong goals has been to connect and inspire people to look more closely at the world around them. Perhaps the most important, yet overlooked groups of plants, are the humble grasses. These beautiful plants support the people, livestock and wildlife of Laikipia. A first step to better understanding the world around us is identifying the things we see. I finally completed a popular guide, 'The Grasses of East Africa' to serve as an introductory guide for students, scientists and naturalists. This will be published shortly by Penguin RandomHouse Struik. Closely observing and drawing the different species has taught me so much about how important and connected they are to us.

– Dino J. Martins



Black Rhino: Connecting An Endangered Species, Conservation and Tourism in Laikipia



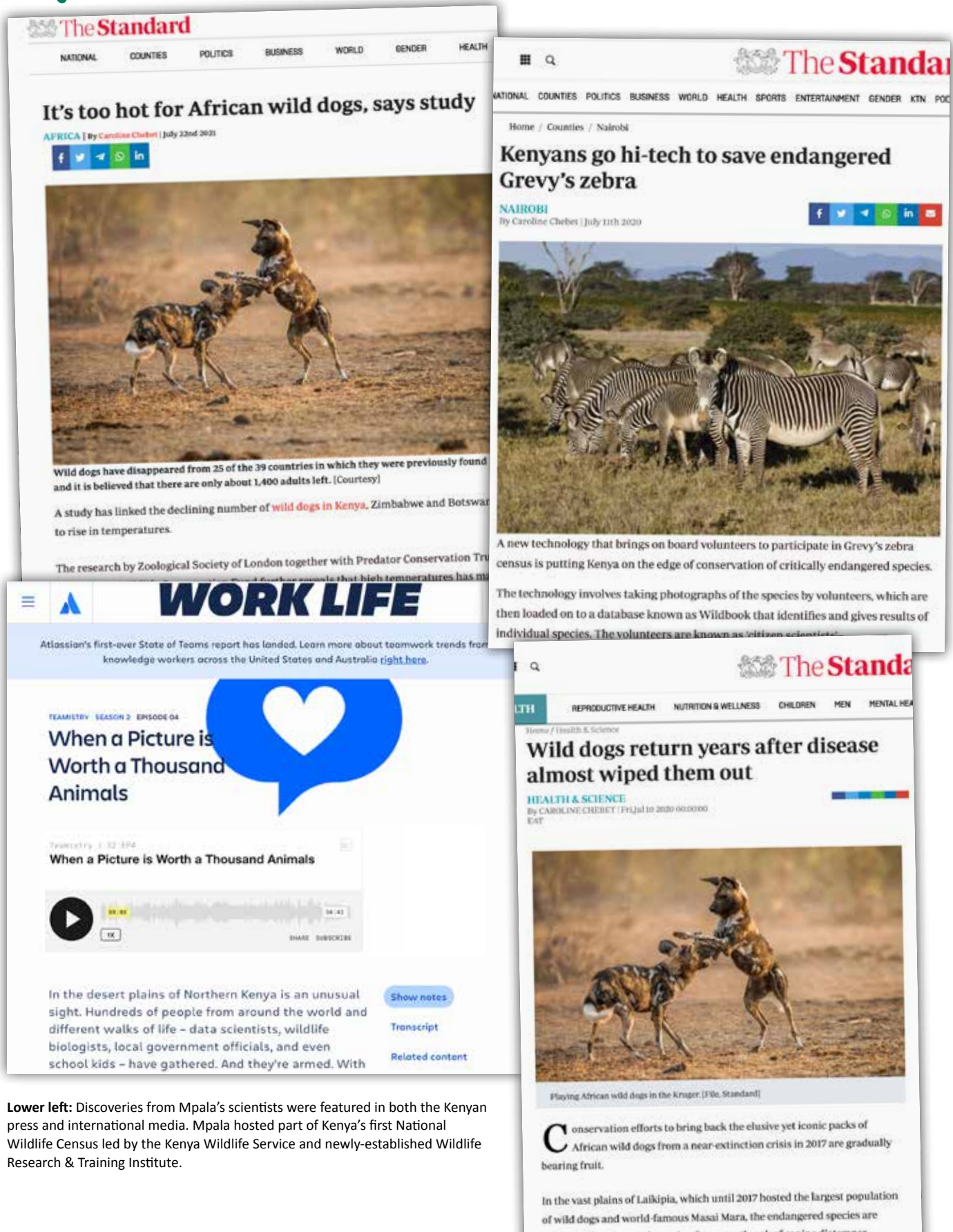
Cosmas Nzomo our Logistics Manager undertook his Masters in Science degree in Tourism Management at Kenyatta University alongside his day to day work at Mpala. Consequently, his recent study on -Wildlife Conservation, Visitors' Preferences And Habitat Conditions For Wildlife Tourism At Oljogi Conservancy was published in the International Academic Journal of Social Sciences and Education as well as the Society for Conservation Biology, both in year 2020. In addition, it was also featured in the Star Newspaper on 11/11/2021 under the Conservation category.

As per the Star article, the study involved 350 tourists visiting Oljogi conservancy in Laikipia. This conservancy received both international and local tourists round the clock. Much as the black rhino was a magnet for tourists arriving in Kenya, they also were the preferred target species for poachers as well.

As per the study, it has taken 20 years of relentless work by stakeholders to pull the black rhino back from the brink in Africa, with their numbers having doubled from a historic low 20 years ago to 5,455 in 2018. In Kenya and according to the National wildlife census 2021 report, the future of the black is of critical importance to the government.

Black rhino is also a species of conservation concern following a dramatic reduction in their population in the 1970s and early 1980s from approximately 20,000 as a result of the illegal trade in their horn to fewer than 400 animals in 1987. Kenya has the third largest population of rhinos in Africa after South Africa and Namibia, having a total rhino population of 1,605 of which 853 are black as at the end of 2020. This clearly shows that the black rhino continues to be critically endangered, and to bring the numbers up to even a fraction of its earlier population estimates would be a bigger feat.

Mpala in the News!



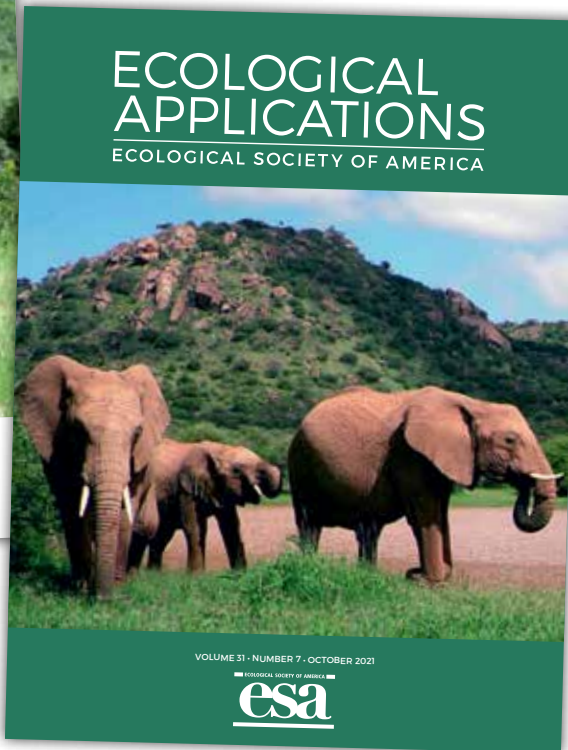
Lower left: Discoveries from Mpala's scientists were featured in both the Kenyan press and international media. Mpala hosted part of Kenya's first National Wildlife Census led by the Kenya Wildlife Service and newly-established Wildlife Research & Training Institute.

Large herbivores in Kenya and their effects on vegetation



WILEY

Above: Biotropica cover - Reticulated giraffe (*Giraffa camelopardalis reticulata*) resting at the bottom of an escarpment at Mpala Research Center in Kenya. Giraffes and elephants exert significant browsing pressure on vegetation in African savannas, but as these megaherbivores tend to avoid steep slopes, trees in these locations are far less vulnerable. Photo credit: Dr. D. K. Kimuyu.



Left: Ecological Applications cover - Large mammalian herbivores sculpt plant communities across savanna landscapes, and their impacts are pronounced around resource hotspots. Titcomb et al. (this issue; Article e02422) investigated the effects of large herbivores on plant communities around water sources, showing that the degree and direction of plant diversity responses to herbivores depended on soil properties and rainfall. Elephants (*Loxodonta africana*) such as those pictured here at Mpala Research Centre are key drivers of plant communities around water sources due to their dependence on water and ability to consume large volumes of plant material. Photo credit: John Naisikie Mantas.

Below: The Star - Wildlife Census

BIG READ / COUNTING TO PROTECT

It's a sight that's been seen for decades: a herd of elephants grazing near a body of water in the savanna. But now, it's a sight that's being counted. The Kenya Wildlife Service (KWS) is conducting a massive wildlife census, the first of its kind in the country. The census is being conducted by a team of KWS staff and volunteers, using a combination of ground and aerial surveys. The goal is to get a more accurate picture of the wildlife population in Kenya, which will help inform conservation efforts.

INSIDE KENYA'S FIRST EVER WILDLIFE CENSUS

Each survey is done by an aircraft with a pilot and three observers

BY MICHAEL NICHOLSON

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THE CHALLENGE

Kenya is home to a vast and diverse wildlife population, but it's also a country with a long history of human-wildlife conflict. The KWS is facing a number of challenges in conducting this census, including the need to cover a large area of land and the need to ensure that the census is as accurate as possible. The KWS is using a combination of ground and aerial surveys to overcome these challenges.

THE PROCESS

The census is being conducted in a number of stages. The first stage is a ground survey, where KWS staff and volunteers are going out into the field to count the number of animals they see. The second stage is an aerial survey, where a team of KWS staff and volunteers are flying over the savanna in a small aircraft, counting the number of animals they see from above. The third stage is a data analysis, where the KWS staff are putting together the data from the ground and aerial surveys to get a more accurate picture of the wildlife population.

THE RESULTS

The KWS is hoping to get a more accurate picture of the wildlife population in Kenya, which will help inform conservation efforts. The census is a major milestone for the KWS, and it's a testament to the dedication of the KWS staff and volunteers who are working to protect Kenya's wildlife.

THE LIE OF THE LAND

80% OF KENYA'S WILDLIFE IS IN THE HANDS OF A FEW PEOPLE

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10% OF KENYA'S WILDLIFE IS IN THE HANDS OF A FEW PEOPLE

20% OF KENYA'S WILDLIFE IS IN THE HANDS OF A FEW PEOPLE

30% OF KENYA'S WILDLIFE IS IN THE HANDS OF A FEW PEOPLE

40% OF KENYA'S WILDLIFE IS IN THE HANDS OF A FEW PEOPLE

50% OF KENYA'S WILDLIFE IS IN THE HANDS OF A FEW PEOPLE

60% OF KENYA'S WILDLIFE IS IN THE HANDS OF A FEW PEOPLE

70% OF KENYA'S WILDLIFE IS IN THE HANDS OF A FEW PEOPLE

80% OF KENYA'S WILDLIFE IS IN THE HANDS OF A FEW PEOPLE

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What it takes to carry out survey

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Restoring a globally endangered African wild dog population

Dedan K. Ngatia
PhD Student, University of Wyoming

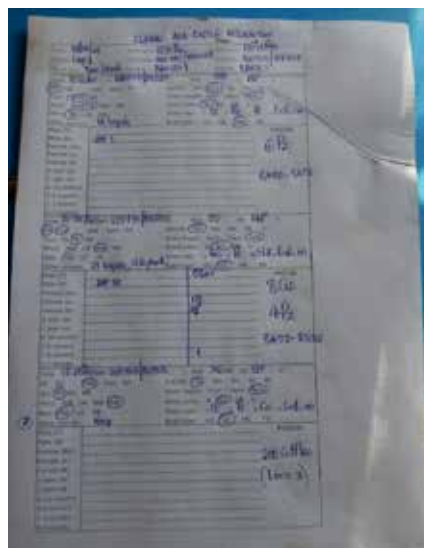
MPALA
THE MPALA RESEARCH CENTRE &
THE MPALA WILDLIFE FOUNDATION

Virtual Mpala

As the global pandemic continued to disrupt travel, the students, scientists and team at Mpala rose to this challenge. We were able to offer a range of courses, internships and

research opportunities online. This was made possible by the team in the field, and the amazing connectivity we now have through better internet and mobile phone networks. Virtual

programs allowed students from Kenyan schools to connect with researchers and a wide, global audience to learn and engage with Mpala.



Handwritten field notebook page with a table of data. The table has columns for 'Date', 'Time', 'Location', 'Observer', 'Species', 'Count', 'Notes', and 'Remarks'. The data is handwritten in blue ink.

Date	Time	Location	Observer	Species	Count	Notes	Remarks
10/10/2020	08:00	MPALA	Ngatia	Wild Dog	1		
10/10/2020	08:15	MPALA	Ngatia	Wild Dog	1		
10/10/2020	08:30	MPALA	Ngatia	Wild Dog	1		
10/10/2020	08:45	MPALA	Ngatia	Wild Dog	1		
10/10/2020	09:00	MPALA	Ngatia	Wild Dog	1		
10/10/2020	09:15	MPALA	Ngatia	Wild Dog	1		
10/10/2020	09:30	MPALA	Ngatia	Wild Dog	1		
10/10/2020	09:45	MPALA	Ngatia	Wild Dog	1		
10/10/2020	10:00	MPALA	Ngatia	Wild Dog	1		
10/10/2020	10:15	MPALA	Ngatia	Wild Dog	1		
10/10/2020	10:30	MPALA	Ngatia	Wild Dog	1		
10/10/2020	10:45	MPALA	Ngatia	Wild Dog	1		
10/10/2020	11:00	MPALA	Ngatia	Wild Dog	1		
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10/10/2020	11:30	MPALA	Ngatia	Wild Dog	1		
10/10/2020	11:45	MPALA	Ngatia	Wild Dog	1		
10/10/2020	12:00	MPALA	Ngatia	Wild Dog	1		
10/10/2020	12:15	MPALA	Ngatia	Wild Dog	1		
10/10/2020	12:30	MPALA	Ngatia	Wild Dog	1		
10/10/2020	12:45	MPALA	Ngatia	Wild Dog	1		
10/10/2020	13:00	MPALA	Ngatia	Wild Dog	1		
10/10/2020	13:15	MPALA	Ngatia	Wild Dog	1		
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10/10/2020	22:30	MPALA	Ngatia	Wild Dog	1		
10/10/2020	22:45	MPALA	Ngatia	Wild Dog	1		
10/10/2020	23:00	MPALA	Ngatia	Wild Dog	1		
10/10/2020	23:15	MPALA	Ngatia	Wild Dog	1		
10/10/2020	23:30	MPALA	Ngatia	Wild Dog	1		
10/10/2020	23:45	MPALA	Ngatia	Wild Dog	1		
10/10/2020	24:00	MPALA	Ngatia	Wild Dog	1		



WHAT MAKES DARAJA UNIQUE?



W.I.S.H
 Women of Integrity, Strength, and Hope
 Daraja is four-year empowerment & leadership class that focuses on confidence and public speaking, student identity, leadership, Peace and conflict resolution, Just Human rights & social justice.



STUDENTS SELECTION
 Girls are interviewed and selected from all parts of Kenya. Based on the relatively high K.C.P.E scores, leadership skills, the financial need of the family.



TRANSITION PROGRAM
 The five-month, postgraduate Program provides Daraja graduates with skills in IT, communication, personal finances, entrepreneurship, social change, etc. The program continues with a six-week internship in various organizations.





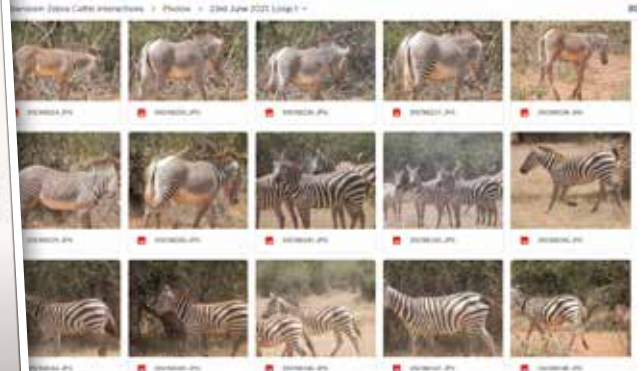
Presentation Daraja Academy.pdf (page 1 of 14)





Daraja
 DARAJA ACADEMY / EDUCATING LEADERS

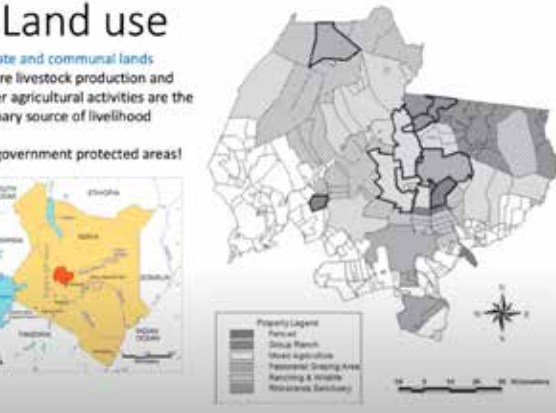
More than 10 years of Educating and empowering girls from poverty to become community leaders.



Land use

Private and communal lands are used for livestock production and agricultural activities are the primary source of livelihood.

Government protected areas



Property Legend

- Private
- State
- Mixed Agriculture
- Protected Grazing Area
- Residential & Wildlife
- Residential (Settlement)



INTRODUCTION TO ONE HEALTH



Dr. Maureen Kamau (BVM)





Screenshots of some of our 2020/2021 Virtual classes as the students engage with the Mpala team.

Glimpses of Wildlife From Mpala



Birdlife at Mpala.
Clockwise from top
left: Verreaux's Eagle
Owl, Grey-Headed
Kingfisher, Vulturine
Guineafowl, Chin-
Spot Batis, Purple
Grenadier.





Clockwise from top:
Cheetah, Purple Roller,
the Wild Dogs are doing
well, a praying mantis
on an aloe, emergence
of Brown-veined white
butterflies.



Mpalalumni Around the World!

Ciara Nutter

After finishing her fellowship at Mpala, Ciara returned to Princeton University's Department of Ecology and Evolutionary Biology as a Research Specialist in Dr. Robert Pringle's lab where she continues to pursue a career in wildlife conservation research.

Benjamin Muhoya

Benjamin Muhoya who worked in the Turkana Genomics Lab at Mpala is now a graduate Student at Princeton University taking a PhD in Ecology and Evolutionary Biology. Prior to joining Princeton, Benjamin worked as a research assistant with the Turkana Health and Genomics Project; he played an integral role leading up to recent discoveries showing a strong link between a high index of urbanisation and poor cardiometabolic health outcomes. This line of research has gathered much interest over the recent past given that cardiometabolic disorders are in a pandemic rise all over the world and especially in developing countries such as Kenya that are experiencing rapid urbanization. For his PhD Project at Princeton, Benjamin hopes to continue researching cardiometabolic diseases and disentangle the complex interplay between environmental, lifestyle and dietary changes to influence the risk of developing a cardiometabolic disease. Additionally, Benjamin hopes to mentor other young Scientists into Science Careers to increase research capacity in Kenya and beyond.



Benjamin Muhoya



Patrick Milligan

Patrick Milligan is working as a Postdoctoral Research Fellow in Biology (supported by the US National Science Foundation) supervised by Dr. Elizabeth Pringle (University of Nevada, Reno), Dr. Bridgett vonHoldt (Princeton University), and Dr. Rebecca Kartzinel (Brown University). He is establishing a project that will run for the next 2-3 years, where we will study how cooperative acacia-dwelling ants affect the physiology and epigenetics of their host tree. Our work involves field measurements of the carbon dioxide going in and water vapor being lost from acacia leaves (the two major gases involved in photosynthesis; using the CIRAS-3 Portable Photosynthesis System), as well as lab analysis of tree tissues to measure carbohydrates (the main product of photosynthesis) and epigenetic patterns. Dr. Milligan measures photosynthetic traits of whistling acacia saplings.

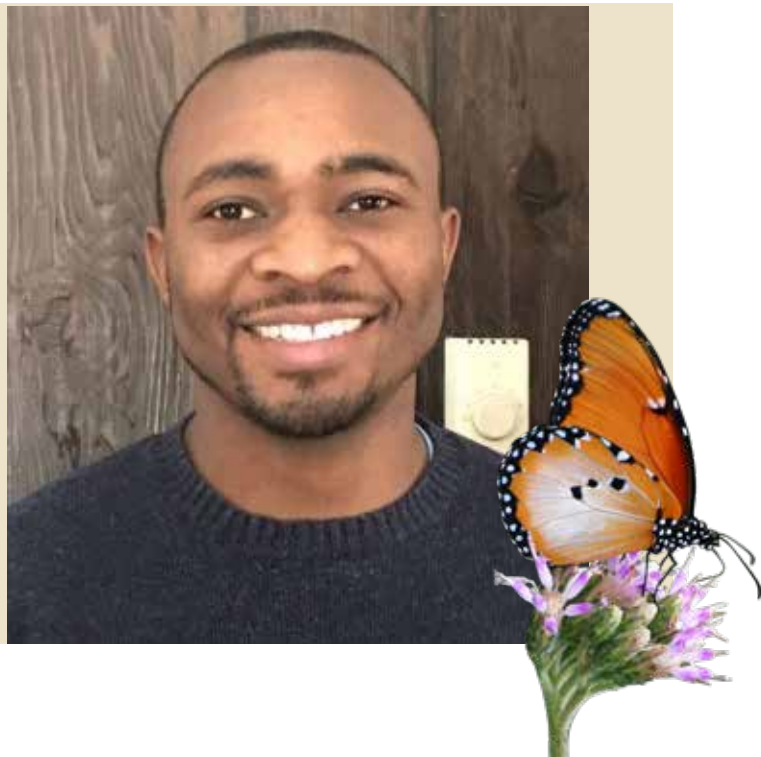


Dr. Sharon Mulindi BVM

After completing her internship at Mpala, Sharon Mulindi went on to undertake her mandatory 1-year government internship at the Kenya Wildlife Service where she was placed to work in the Mt. Kenya/Laikipia Mobile Veterinary Unit. Sharon was able to get a job at Save The Elephants as the Veterinary assistant to the Northern Kenya Mobile Veterinary unit, where she assists the vet team with clinical interventions, sampling and veterinary research. Sharon is extremely grateful as all her experiences have allowed her to work in wildlife conservation and research, doing what she loves and learning as much as she can.

Kennedy Saitoti

Kennedy Saitoti was a masters student working in the Insect-plant interactions lab under Dr. Dino J. Martins at Mpala Research Centre. He found his passion for ecology and evolution while working with researchers studying the African Queen butterfly. As a graduate student in the Kocher Lab at Princeton University, he is studying the interplay of genes and the environment in regulating and shaping the behavior and physiology of halictid bees.



Zoe Sims

Zoe Sims, a former Princeton-in-Africa Fellow at Mpala is now working at the State Legislature in Hawaii, where she is from, as Chief of Staff for the Chairperson of the House of Representatives' Water and Land Committee. Her current work focuses on natural resource management and environmental policy. In 2022, she plans to begin a Ph. D studying the ecology of agricultural ecosystems with environmental policy implications.

**Ray Schmidt**

Ray Schmidt, who was a Smithsonian-Mpala postdoctoral fellow is currently a Visiting Assistant Professor at Randolph-Macon College (near Richmond, Virginia USA) and a research associate at the Smithsonian Institution National Museum of Natural History. Since leaving Mpala he has continued his research on the diversity of African freshwater fishes, notably an expedition funded by the National Geographic Society to Equatorial Guinea yield many new species and other discoveries. Undergraduate students in his research contribute to this research have helped to identify and describe new species of threatened fishes in East, West, and central Africa. In addition to these studies he is also contributing to the IUCN Red List assessments for threatened species of fishes and other freshwater taxa; coauthoring a chapter on the freshwater fishes in the most recent assessment on the freshwater biodiversity in West Africa. Ray also received funding to study the freshwater diversity in western Kenya for three years. This study has been postponed due to the ongoing COVID19 pandemic, but hopefully that project can begin soon.





Megan McDaniels

Megan McDaniels (Princeton in Africa Science Fellow 2019-2020) lives in Washington, D.C. and is a research technician with the Smithsonian Conservation Biology Institute and Clifton Institute, and a research assistant with Wild Me, a technology nonprofit developing machine learning tools to support conservation. In these roles, Megan has been contributing to projects exploring the behavior and habitat use of American kestrels, training machine learning tools to individually identify Grevy's zebra, and supporting the development of the first country-wide catalogue of individually-identified humpback whales in Iceland. She has also been researching human-elephant conflict patterns in the Okavango Delta, Botswana. "My experiences living and working at Mpala has been pivotal in my professional and academic journey and personal worldview. I gained an incredible breadth of knowledge about savanna ecology while working alongside Kenyan and international researchers and students, and built deep friendships and understanding through conversations over chai and on game drives. Mpala will always have a very special place in my heart!"

Elaina Gu

Elaina Gu, a former Princeton in Africa Education fellow 2019-2020 is currently working at an Obstetrics and Gynecology office to gain experience in the healthcare field. She will be applying to Physicians Assistant school next fall and hope to start the program in the fall of 2023!



Katrina Nyawira

After completing her internship at Mpala, Katrina Nyawira went to the UK to continue with her studies and recently graduated with an Msc. Conservation Ecology from Oxford Brookes University. Katrina currently works at Friends of Karura Forest heading their Research Department.





Leopard Conservation Program, San Diego Zoo Wildlife Alliance

By Laiyon Lenguya – Program Coordinator

Introduction

African leopards are the most elusive of the big cats and little is known about their population status in Kenya. The Uhifadhi Wa Chui (Leopard Conservation) team is working to establish their population dynamics in Laikipia, including at Mpala. By using a specialized grid of cameras and the unique coat patterns of the leopards that are akin to a fingerprint, the Uhifadhi Wa Chui team is able to track individual leopards through time, to understand the survival, reproduction, and overall health of the population. Through our camera trap network, we estimate that 20-30 leopards reside at Mpala.



Lekiji Community Work

Human carnivore co-existence depends on the socio-economic and livestock loss pressure. Changing local community attitudes, perceptions, and views on co-existing with large carnivores is instrumental in such a diverse and changing Landscape. To better our understanding of how large carnivores influence livestock husbandry, Uhifadhi Wa Chui through the 20 local community reporting network collects the conflicts data using ArcGis survey 123 software. Lekiji community, for example, has two enumerators reporting these depredation cases as they occur. In addressing these conflicts, we installed 12 bomas with predator-proof wires and lights in March 2021, at Lekiji. Since then, no single case was observed inside the reinforced bomas, positively impacting the local community economies and improving general co-existence with large carnivores.





Northern Kenya Conservation Clubs (NKCC)

By Everlyne Ndinda



Photos: Everlyne Ndinda

The Northern Kenya Conservation Clubs were started in the year 2008. They were an outreach program, for Professor Dan Rubenstein's research on Grevy's zebra in Samburu. By 2009, there were conservation clubs in four primary schools namely, Mpala, Il Motiok, Naiperere, and Ewaso. Professor Dan, Nancy Rubenstein, NKCC teachers, educators from Saint Louis and San Diego zoos held a workshop with members from group ranches to develop a curriculum for the clubs. Today the clubs reaches out to 14 Primary schools and 3 secondary schools.

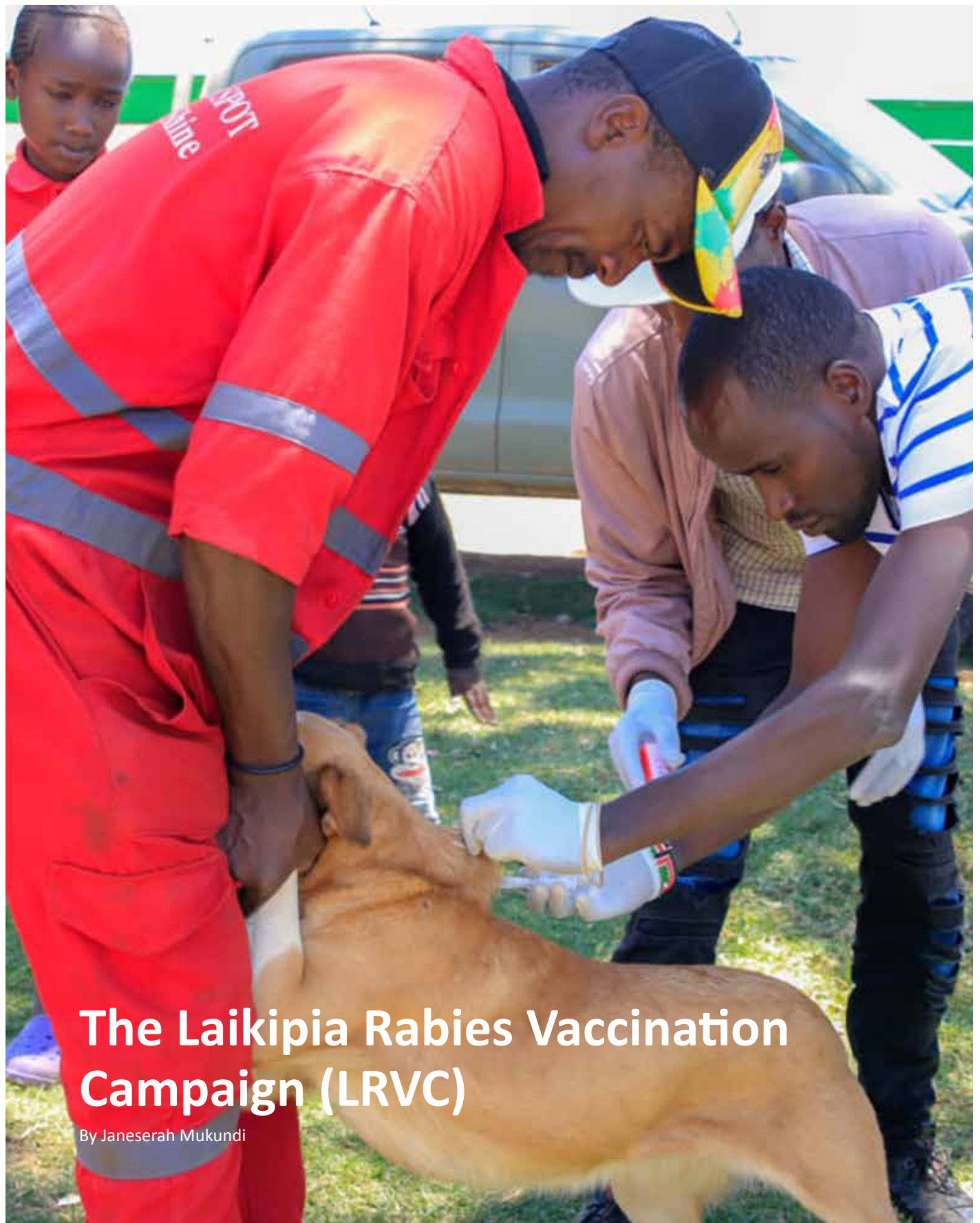
The clubs have both short term, long term and continuous projects. The short term projects last for a term or a few weeks, long term projects may take a few years to be completed and usually the current members may not be able to see the completion of such projects including, afforestation, beekeeping, soil erosion etc.

The year 2021, this program has been running though slowly, due to COVID-19 restrictions, we have not been fully active.

We held our 2021 teachers' workshop to empower and encourage them to keep teaching students back in their schools.

Northern Kenya Conservation club through our philosophy of experiential learning continue to impact knowledge, skills and action competence required to make students aware of their environment, which we know will make them future conservationist. Through our WhatsApp groups, we have kept in touch with the conservation teachers. We remind them conserving our environment is a process and a journey that we should all support.





The Laikipia Rabies Vaccination Campaign (LRVC)

By Janeserah Mukundi

The annual Laikipia rabies vaccination campaign has been one of the most looked forward to campaigns over the years. The campaign, started in 2015 and has brought about various stakeholders with a vision of eradicating rabies in Laikipia county by bringing mass vaccination to rural communities where mass vaccination efforts are challenging and limited. In addition, mass vaccination of dogs and cats remains the most cost-effective intervention method of controlling rabies and transmission to humans.

The ambitious campaign has seen a gradual rise in the number of vaccinated animals with 2020 having no exceptions. The 2020 campaign brought together stakeholders and support from the community, Mpala, the Laikipia County Government, IUCN Save our Species, co-funded by the European Union, and International Union for Conservation of Nature.

For 10 weeks, the team vaccinated 21,491 dogs and cats, breaking a new record high from the 13, 185 animals vaccinated in 2019, despite the COVID-19 challenges and strict Ministry of Health protocols.

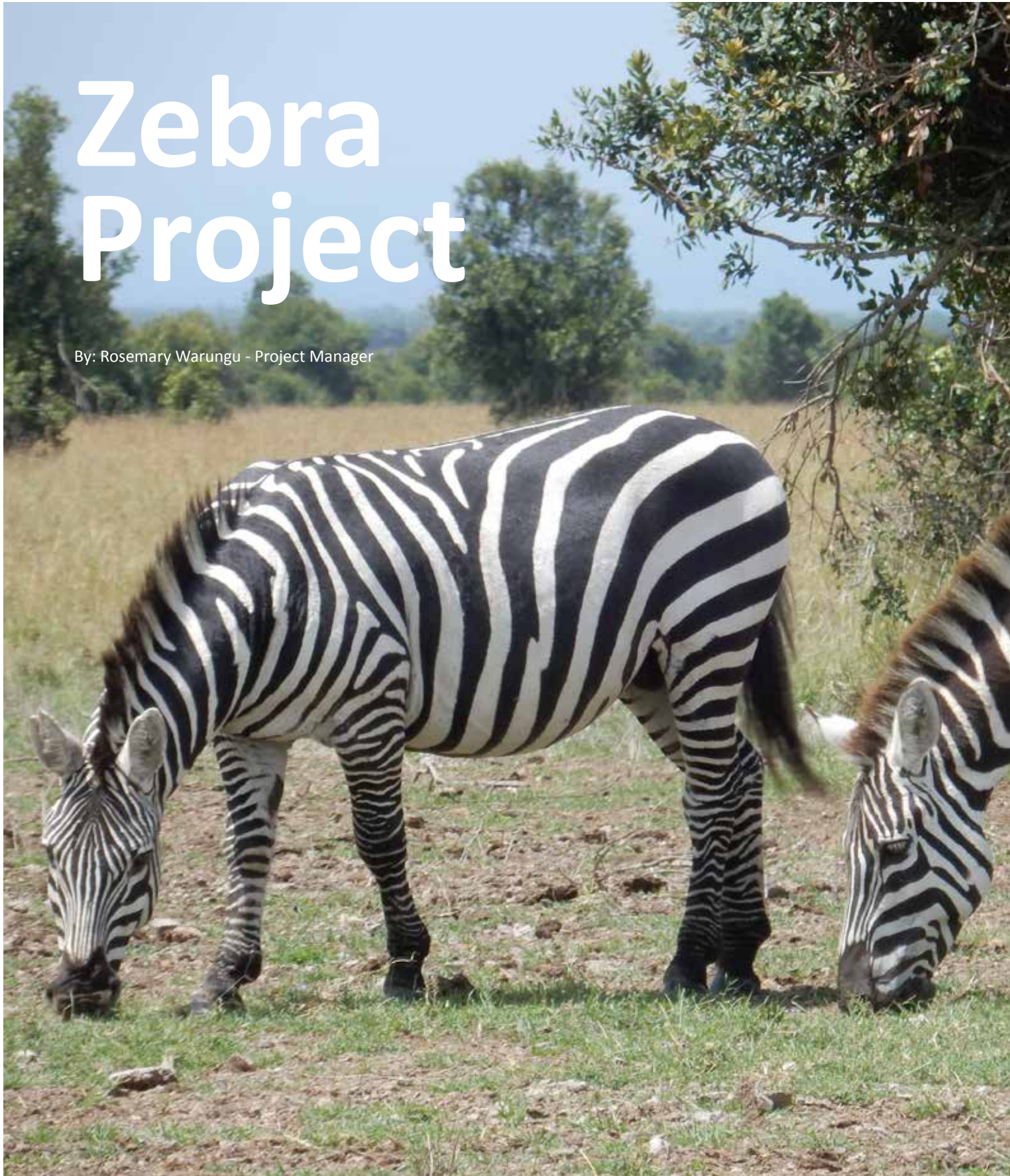


***We vaccinated a record
21,491 dogs and cats in
this campaign!***



Zebra Project

By: Rosemary Warungu - Project Manager



Photos: Rosemary Warungu



The Mpala Zebra Project is multifaceted. Not only does it examine the basic ecology, behaviour and demography of both plains and Grevy's zebras on Mpala and neighbouring conservancies and group ranches, it examines issues of human-wildlife interaction, especially with respect to cattle and human economic and social wellbeing.

Zebra Demography, Habitat Choice and Movement Ecology

To determine the demographic structure and stability of zebra populations we record the individual identity and habitat locations of Grevy's and Plain zebras across seasons in Laikipia, mainly on Ol Jogi, Mpala and Ol Pejeta Conservancies. We drive predetermined loops taking photos of all individual zebras, recording reproductive status and habitat within the group. Individual identities are determined from these images using the Detection and Hotspotter algorithms of WILDBOOK which we have been instrumental in helping develop. From repeated sightings we can assess seasonal ranging, habitat preferences as well as demographic features associated with survival and reproduction.

Even though COVID-19 slowed many activities, we were able to proceed with our projects as follows.

The Great Grevy Rally (GGR) Results

We participated third national census of Grevy's zebra on the 25th and 26th of January 2020 where tens of thousands of photos were taken within the 25,000km² area of the Grevy's zebras Kenya range. GGR brings together scientists, landowners, conservancies and members of the public in driving through designated areas and photographing the right side of each individual Grevy's zebra observed with a provided GPS enabled digital camera. Each Grevy's zebra has a unique stripe pattern which allows WILDBOOK to identify individuals from photographs taken on two consecutive days. From these sight-resighting we can estimate the size of the Grevy's zebra population nationally, by county and even by property.

Due to COVID-19 pandemic globally, we were not able to identify all photos taken during the rally thus the delay in producing the national census results. Identification is ongoing. We are welcoming more people to attend and participate in the fourth Great Grevy's Rally in January 2022. We are optimistic that the endangered Grevy zebra will be on the increase or have a stable population.

Grevy's Zebra Genetics

The zebra genetics analysis helps to determine the degree of population mixing, sub structuring and possible inbreeding. The total genomic analysis also reveals which traits are undergoing selection and what genetic bottlenecks have existed throughout the population in the past.



This year, the Mpala zebra genetics lab is focusing on the degree of genetic similarity with image similarity. The sampling will help with:

1. Determine the genome of individual Grevy's zebras;
2. The diets of Grevy's zebras over time since there will be many repeat samples
3. The microbiome of the zebras that will be associated with the season diets.

Zebra Stripes

One of the fundamental unanswered questions that remains unresolved is 'why do zebras have stripes'? Many possible explanations have been proposed, ranging from confusing attacking predators, to enhancing social cohesion, to reducing biting by disease carrying flies, to regulating body temperature. To date the best empirical evidence supports the hypothesis that stripes make it harder for flies to detect zebras at a distance. Experiments we conducted by putting hides of zebras and dun colored mammals in a plexiglass chamber with *Stomoxys* (stable) flies reaffirmed this result and showed for the first time that these flies equally avoided skins of both zebra species irrespective of their stripe thickness.

With respect to fostering social cohesion, we have also shown that both melanic (mostly black) and white (cream colored with white stripes) zebras are not socially ostracized and have high reproductive success. Consequently, they do not suffer reductions in reproductive success.

Evidence supporting the 'dazzle confusion' and temperature regulation hypotheses are harder to come by. Last year, filling 10-liter water bottles covered with black cloth (like a cape buffalo), white cloth (like a white zebra) and striped cloth (like a true zebra) with either cold (17°C) or hot (55°C) water, we showed that bottles with stripes heated less than expected by their 50% black and cooled faster than all white bottles. And surface temperatures were also lower on the striped bottles when compared to the solid-colored ones. This demonstrates that more is going on than passive absorption of solar radiation or reflection. Some sort of active process, most likely convective flow, is involved. But do these temperature dynamics occur in living organisms. Since we can't work closely with actual zebras, we spray painted donkeys white and then spray painted them again with black stripes. We also attached topical iThermometers to measure core body temperature which were transmitted



Left: Grazing are spray painted donkeys with the aim of studying the core body temperature dynamics.

Above: Severine Hex in the field collecting data.

to our smartphones. And we used our infrared sensing gun to measure surface temperatures. As with actual zebras, the surface temperatures of the striped donkeys were lower than the unpainted controls roaming in the same herd. But most intriguingly, the core temperatures were lower than the controls as well. Unfortunately, the summer was overcast most days, so sample sizes are small and the experiments need to be expanded. But the trend is suggestive that stripes can lead to cooling of both the surface and internal body. As a result, stripes seem to reduce biting by flies while at the same time enabling rapid cooling when heating has reached harmful levels.

Princeton Students Course Work

This year we missed Princeton University Graduate Course due to the pandemic. We hosted few researchers among them 2 from Princeton University who have been collecting zebra data at Mpala and the neighbouring conservancies for the last three years. This includes:

- Severine Hex. She is studying Social Behavior, Cognition, Communication, and Development in the Plains Zebra

- Her research seeks to answer two broad questions:
 1. How are multimodal and multicomponent signals used and combined in different social and environmental contexts?
 2. How do individuals in different social positions and life stages use multimodal communication to navigate their social worlds
- **Andrew Gersick** Studying Plain Zebra communication and social behavior
- **Sara Beery**. She is a graduate student from Cal Tech, who is assessing habitat preferences and the different biases that are associated with different camera positioning's on Mpala.

Cattle project

Two cattle projects have taken place over the last few years. As a continuation of a previous experiment, a herd of 16 cattle were selected and divided into 4 herds. Each animal is weighed every two weeks to assess growth performance under supplemented (silage, phosphorous or in combination)

and non-supplemented conditions during a dry period transitioning to a wet period. Dung samples were also collected and preserved for metabarcoding of the diet and of the microbiome.

The new treatments also involve supplemented and non-supplemented treatments, but this time the transition is from wet to dry periods. The 4 treatments were:

4. Control—the cows simply graze while free ranging getting no supplement.
5. Hay—the cows will just get hay to prep their systems for the senescent grass they will experience for the next few months.
6. Molasses—the cows will have some of the range sprayed with molasses, so the cows get energy, but no additional nutrition as would be the case with the hay
7. Both Hay and Molasses—the cows will get both energy and nutrients as well as free-range.

The second cattle project entailed understanding what impact intensive cattle grazing has on zebra habitat use.

To measure this impact, we used our stripe recognition

algorithms embedded in WILDBOOK to look at the behavior of individual plains and Grevy's zebras before cattle arrived in an area, during co-occupancy and when possible, after the cattle were moved to other pastures. We found that cattle do impact zebras, but their impacts differ both by zebra species and by climate. In a wet year when soil moisture facilitated grass regrowth after moderate grazing, the presence of cattle caused most zebras to abandon the area, at least until the cattle were moved elsewhere. Plains zebras moved the most and aggregated around permanent water, but the more water independent Grevy's zebras only moved to the edge of where the cattle were grazing. And when the cows moved on, most of the Grevy's zebras returned while the plains zebras did not. This pattern of habitat use changed markedly during this summer's severe drought. With dams dry, and one river no longer flowing all livestock and wildlife had to drink from one point on the river that still had water. The water independent Grevy's zebras avoided competition by moving out of the range used by the cattle and only went to water briefly to drink every few days. The more water dependent plains zebras, however, had to drink every day like the cows. Consequently, they could not abandon the area. Instead, they reduced their herd sizes and spread out dispersing



themselves lightly across the area where the cows regularly grazed. In this way, both species reduced their head-to-head competition with cattle, but they did so by using very different behavioral strategies depending on how closely tied to water they were. Interestingly, the zebras of both species that we repeatedly saw based on their striped patterns, showed less overall movement in both years than those who were only seen once. This strongly suggests that there are both resident and itinerant zebras and that knowledge of the landscape by residents leads to fewer metabolically expensive movements on the impacted landscape.

Farm Project

While much of Laikipia is too dry for farming, lands along the Nanyuki River are plowed and draw water from the river to grow crops. Traditionally, the fields are flooded with thousands of liters of water weekly which dries the river and leads to conflict with cattle ranchers and herders downstream. It is also wasteful since 50% of the water is lost via evaporation. To better understand crop farming we have begun experiments on the effectiveness of alternative irrigation schemes, in particular flood v. drip irrigation. In this way, we hope to determine the degree to which better water stewardship

affects farm productivity, incomes and human-human conflict.

While water limitation represents one challenge to crop farming, free-ranging wildlife represents another. To better understand what impact baboons and elephants, in particular, have on crop yields and quality, camera traps have been deployed on 3 different farms to examine how wildlife refuges and different farming practices together influence crop yield, loss to wildlife raiders and thus overall farm productivity. Via these comparisons we hope to identify economically effective ways to attenuate human-wildlife tensions. In addition to water shortage and free ranging wildlife, farmers incurred a great loss due to Covid 19 pandemic. Produce that are normally exported like French beans were rejected by the export companies due to lack of market from outside countries. Farmers were forced to sell locally at a low price and a bigger percentage went to waste.

Lower left: Margaret Mwangi and Timothy Epuyo collecting samples in the field.



Karibuni: Welcoming New Fellows

Dr. David Kimutai Melly

Dr. David Melly is a lecturer at Bomet University College - a constituent College of Moi University School of Pure and Applied Science. He received the Smithsonian Mpala Postdoctoral Fellowship 2021 to work the Conservation checklist of total herbaceous vascular plants in Mpala 120-Ha Long-term Monitoring Plot.

Dr. Melly has previously worked on the first census of the Mpala 120-Ha Long-term Monitoring Plot at Mpala Research Centre and worked extensively on floristic studies of Nandi Forests, Aberdare Ranges Forest and Taita Hills Forests, this has led to discovery of several new species and new records for Kenya.

The Postdoc research aims at focusing on the collection and identification of all herbaceous and free-standing shrubs and compile a checklist of all vascular plants that occur in the Mpala plot.

It will also develop a digital database from quality pictures of all the plants collected that can ultimately be used to produce a field guide for plants of Mpala. Finally, the research will investigate how herbaceous plants are associated to the four topographic habitats defined in the 120-ha plot.



Dr. Shaleen Angwenyi

Dr. Shaleen Angwenyi is a wildlife veterinarian joining Mpala for 2 years as a Smithsonian Mpala postdoctoral research fellow.

The understanding of the effects of stress on the immune function of wildlife as well as the disease dynamics in wildlife is wanting. More attention needs to be focused on studying the connections between stress and disease, and how these outcomes emerge from human activities such as habitat fragmentation, climate change and conservation management interventions. Stress can cause an imbalance between hosts and their parasites, resulting in increased susceptibility to infection and increased shedding of infectious agents. However, the finer-scale connections between stress and specific pathogens that pose a threat to endangered wildlife are poorly understood.

The aim of Dr. Angwenyi's study is to determine if rhino management interventions put black rhinos at an increased risk of morbidity due to enteric clostridial disease.

Her objectives include:

- Establishing a baseline for the bacterial load of *C. perfringens* in black rhino faeces.
- Quantifying the load of *C. perfringens* and *C. difficile* in faeces from black rhinos subjected to notching and translocations and establish a correlation between this load and the stress levels during and post-interventions.
- Determining whether there is an association between the faecal shedding of *C. perfringens* and host factors, environmental factors, and different management activities.





Dr. Maureen Kamau

Dr. Maureen Kamau is a veterinary research fellow in One Health with the Smithsonian Global health program and working with the REDI-NET (Remote Emerging Disease Intelligence Network).

Some of the most devastating global zoonotic diseases (e.g. Ebola, Yellow fever, Zika) have their origins in African vertebrates. They spread to new regions and/or countries through large scale animal, human or vector interactions, causing dramatic impacts on human health. An approach to informed, actionable intelligence on the distribution, prevalence and diversity of circulating vector borne pathogens, at the human-wildlife interface in the Laikipia region, with the anticipation of the discovery characterization and early detection of the next potentially global epizootic pathogens is required.

Dr. Kamau's overall objectives include;

- Leverage this opportunity towards a career goal of understanding landscape epidemiology of vector borne diseases, at the human wildlife livestock interface
- Organize an expansive vector borne disease sampling project in Laikipia
- Organize scientific grant administration across multiple funding entities
- To study waterholes as an interface for disease transmission between wildlife and livestock in African grassland landscapes.





Dr. Geoffrey M. Wambugu

Dr. Wambugu joined Mpala in October 2020 for a 2-year postdoc fellowship by the Smithsonian Institution. The research focuses on land use and climate change impacts, on hydro-ecology of rivers in Arid Lands in the Upper Ewaso Ng'iro Basin, Kenya.

The research seeks to;

- Determine the influence of land use activities, in the upper sub watersheds of River Ewaso Ng'iro, on river metabolism
- Determine the influence of land use activities, in the upper sub watersheds of River Ewaso Ng'iro, on macro-invertebrate species richness, and biomarker response
- Determine the combined effects of land use and climate change on macro-invertebrate species composition and diversity on the upper sub watersheds of River Ewaso Ng'iro River.



Khasoha Leo Malingati

Khasoha Leo Malingati

Leo is a PhD student in the Department of Zoology and Physiology at the University of Wyoming, USA under a 5-year NSF scholarship starting in 2020.

He is currently studying a diverse community of approximately 15 species of rodents and shrews in an African savannah at Mpala.

He makes use of long-term data from repeated sampling of small mammals on UHURU experiment, to field test theorized hypothetical explanations for abundance-occupancy relationships.

Leo is currently applying DNA metabarcoding technique, in identifying constituents of the diet of these small mammals. From this, he aims to tell how resource selectivity, shapes abundance and occupancy of Mpala small mammals community. Additionally, he is testing the role of emigration in sustaining the populations of rare species that might be endangered.





Albanus Musyoka

Albanus Musyoka is a Masters student with the University of Nairobi. He has been awarded a 2 year MSc Fellowship that will support and facilitate his fieldwork activities in Laikipia and Samburu counties. The fellowship is a collaboration between Mpala and British Army Training Unit in Kenya (BATUK).

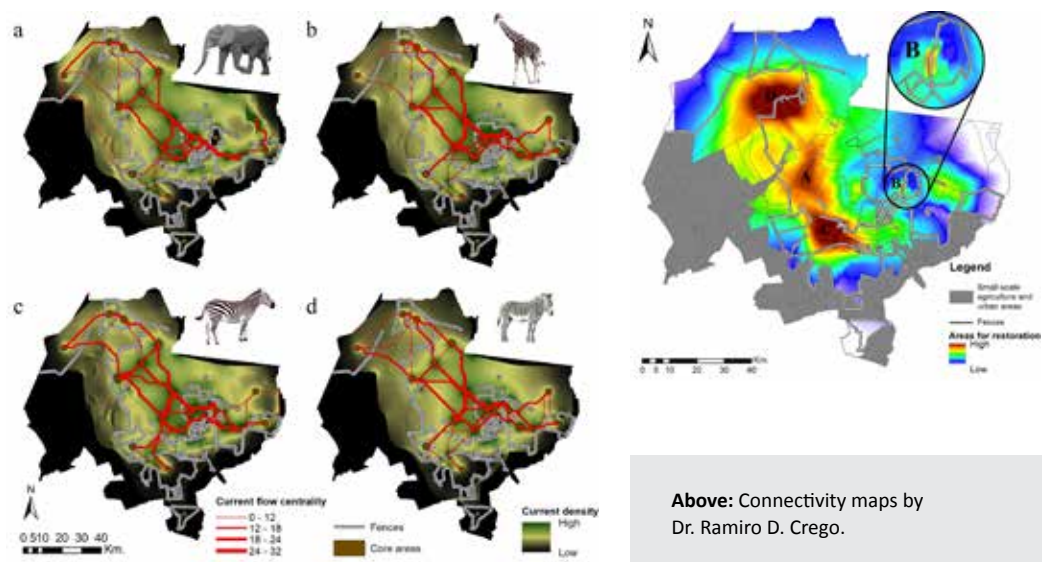
The British Army Training Unit Kenya (BATUK) has been conducting military training in Kenya for the last four decades. A significant part of the British Army training occurs in rangelands and conservancies, which host high number of endangered habitats and diverse assemblage of wildlife. Despite the trainings being conducted in compliance with local legislation to ensure minimal impacts to the environment, potential environmental risks associated with military training activities still exist. It is therefore paramount for BATUK to ensure that natural environmental concerns are fully integrated within operational and training requirements to achieve both training outcomes and environmental protection.

Further, BATUK in collaboration with Mpala Research Centre initiated a rangeland monitoring project aimed at providing baseline information on the status of wildlife and vegetation in military training areas and where required propose mitigation strategies for rangeland restoration. The project is underway in four military training sites: Mpala, Ol Maisor, Ole Naishu



and Archers Post located in the Laikipia-Samburu ecosystem.

At each of the four sites, vegetation surveys and wildlife monitoring has been conducted to assess the ecological impacts arising from military training activities. Preliminary results indicate that both vegetation and wildlife are remarkably resilient to episodic disturbances associated with military training activities. In the next phase of the project, effectiveness of various restoration interventions such as rangeland reseeding, bunched grazing and nutrient additions through cattle dung will be tested. The overall results will provide insights on the extent of impacts of short-term disturbances and



Dr. Ramiro D. Crego

Dr. Ramiro D Crego is a post-doctoral researcher fellow at the Smithsonian Conservation Biology Institute (SCBI) in collaboration with the Mpala Research Centre (2018-2021).

Dr. Crego has been leading a research effort to better understand how dramatic changes in the abundance of livestock and the increase of fences are impacting wild large-herbivore populations and connectivity across the Laikipia plateau in central Kenya. This research has the main goal of providing local stakeholders and scientific partners relevant information to make informed conservation decisions.

The research focused on:

- Investigating wild herbivores spatiotemporal dynamics in species richness and occupancy, and wild herbivore interactions with livestock abundance.
- Investigating how fences are affecting landscape connectivity across Laikipia and identifying areas for restoring movement for large herbivores.
- The research results were made viewable via a customized app.

Dr. Ramiro Crego's work in Laikipia has resulted to 2 papers:

1. Spatiotemporal dynamics of wild herbivore species richness and occupancy across a savannah rangeland: Implications for conservation.

Crego RD, Ogutu JO, Wells HBM, Ojwang GO, Martins DJ, Leimgruber P, Stabach JA. 2020. Biological Conservation 242:108436.

- Using novel techniques to incorporate species detectability from aerial survey data, we modelled trends in herbivore richness and occupancy for the last 20 years.

- We found that wildlife-friendly properties are crucial for wildlife conservation in central Kenya.
- Community properties where pastoralism is practiced and livestock abundance are moderate can support wildlife communities.
- Wild herbivore species richness decreases with increasing livestock abundance.
- Reticulated giraffes, Grevy's zebras, oryx, Defassa waterbuck and gerenuk, all species (or subspecies) with conservation concerns, occupy less than 50% of Laikipia rangelands. Ensuring conservation lands in Laikipia County is crucial for protecting them.

2. Moving through the mosaic: Identifying critical linkage zones for herbivores in African multiple-use landscapes.

Crego, RD, Wells HBM, Ndung'u, KS, Evans L, Njeri Nduguta R, Chege MA, Brown MB, Ogutu JO, Ojwang GO, Fennessy J, O'Connor D, Stacy-Dawes J, Rubenstein DI, Martins DJ, Leimgruber P and Stabach JA. 2021. Landscape Ecology.

- We mapped fences and fence gaps across Laikipia.
- We modeled landscape connectivity among conservancies and identified areas for connectivity restoration.
- We found that conservancies in central Laikipia are well connected. Conservancies in the south and west of Laikipia are being isolated from the center of the landscape by fences, agricultural and degraded lands.
- We identified 4 areas (see restoration map) that are critical for maintaining and/or restoring connectivity across conservancies. One of the most important properties is Eland Downs.

Dr. Katherine Worsley-Tonks & Dr. Christian Odinga

Dr. Katherine Worsley-Tonks is a Postdoctoral Fellow in the Smithsonian's Global Health Program.

Dr. Christian Odinga is a veterinarian and MSc student at the University of Nairobi and affiliated with the Smithsonian's Global Health Program.

Drs. Worsley-Tonks and Odinga aim to assess the success of the Laikipia Rabies Vaccination Campaign (LRVC) that has been running since 2015 and explore the potential to have more targeted approaches to vaccination to help maximize efforts and minimize costs.

Dr. Odinga is leading evaluation of the success of the LRVC by conducting household surveys in 25 communities across Laikipia, and assessing dog owner knowledge of rabies, dog bite treatment options, and dog vaccination.

Dr. Worsley-Tonks is leading the exploration of more targeted approaches to dog vaccination which requires two steps:

- 1) Identifying dogs at greatest risk of rabies infection using rabies surveillance, dog ownership practices, and dog movement data
- 2) Testing whether targeted rabies vaccination is an effective approach for controlling rabies in dogs of Laikipia using mathematical models and a combination of empirical and simulated data.

Findings from this research will be used to guide future LRVC efforts, as well as other vaccination campaigns done in locations with similar ecological and socio-economic attributes.





Richie Graham

Effects of sustainable intensification practices on streamflow and wildlife

By: Lory Willard



Lory Willard Collecting data with a Water Resources Authority staff.

Photos: John Gitonga

This research is aimed at quantifying the effects is conducted by University of Florida and The Nature Conservancy, with support from Mpala Research Centre and CETRAD.

Project overview

As world population increases, agricultural production must increase to meet demand, particularly in food insecure regions. Dr. Cheryl Palm, the project principal investigator (PI) and professor in the University of Florida (UF) Agricultural and Biological Engineering Department, explains, "In contrast to other methods of increasing food production, sustainable agricultural intensification (SAI) aims to produce more food per unit of land while preserving important ecosystem functions, including support of natural water filtration through soils, erosion prevention through natural vegetation root systems, pollinator habitat support, drought mitigation, and carbon storage. These ecosystem functions provide resilience to many system shocks and stresses." Dr. Rafael Muñoz-Carpena (co-PI, UF) adds, "As Kenya, and specifically Laikipia, continues to increase the amount of land under agricultural cultivation supported by growing irrigation demands from the

local streams, it is important to understand the impacts that this could have on the remote downstream savanna region, including water availability for livestock and wildlife during seasonal droughts and dry years."

To research this complex problem, experts with a breadth of knowledge in environmental, agricultural, and hydrologic systems and previous work in Laikipia have partnered together. In addition to Drs. Palm and Muñoz-Carpena and PhD candidates Lory Willard and Taisha Venort (UF), these include Dr. Kelly Caylor (University of California – Santa Barbara), and John Gitonga (Mpala Research Centre). This work is funded by The Nature Conservancy (TNC) and includes collaboration with the local research institution CETRAD.

This study focuses on two sustainable intensification practices, reduced tillage and improved irrigation efficiency, to determine how the adoption of these practices throughout Laikipia could impact downstream hydrology and ecological services. Due to the steep rainfall gradient in Laikipia, where much rainfall occurs closer to Mount Kenya and the climate is much drier in the savanna region, we are interested to see whether SAI practices are more effective for preserving natural (pre-agricultural) hydrology if they are adopted in different locations along the rainfall gradient. For instance,

we hypothesize that reduced tillage may be more effective in dryland areas where crops are able to benefit from improved soil moisture and less water must be taken from the river for sufficient crop yields. We are comparing these practices to extensification, a practice where more food is produced by converting more savanna land to agricultural land, an overall detriment to ecosystem function. In order to conduct this research, we are continuously monitoring the Timau, Likii, and Nanyuki Rivers and rainfall, and analyzing soil samples and land uses and practices throughout the Laikipia region. Results from this study can then be used to inform future sustainable development within Laikipia and other regions under fast development.

Project status

To test the hypotheses within this project, the team is developing a new hydrologic model, CUENCA, calibrated to the Laikipia region that can be used for scenario analysis. The hydrologic and soils data collected in the project are being used to calibrate and test the model to gain confidence on it as an analysis tool for the region. To collect these data, John Gitonga recently managed construction of eight river automated gauging stations with five collocated rain gauges. In addition, soils samples comprising the unique combination of soils types and landcovers in the region are being collected and analyzed for physical and chemical properties that impact

surface and soil hydrology, and carbon and nutrient balances.

While Lory Willard was visiting in August 2021, river and rain gauge data collection began at a 5-minute resolution, with plans to collect these data continuously for at least 18 months. At each river gauge, a rating curve is being developed to relate water level to discharge (flow rate). In addition, cross-sectional profile surveys were conducted in collaboration with the Upper Ewaso Ngiro Water Resources Association (WRA) staff at each river gauge so that the hydraulic gradient, rather than simply depth of water in channel, across the entire watershed can be analyzed during flow events.

Throughout the duration of the project, John Gitonga in close remote collaboration with the UF team handles the many logistical challenges associated with field data collection, including sensor maintenance, protection against vandalism, and transportation and labor. The data sets are uploaded remotely bi-weekly to the UF data servers and web platform for curation and making it available to the project partners. Ultimately, these data increase confidence in the hydrologic model and subsequent scenario analysis, especially in an area where global soils data products have not been field-validated. In addition, are working with our partners in Laikipia, including CETRAD, the WRA, and OI Jogi Conservancy, to ensure the resulting data and model will be pertinent to their ongoing work in the region.



Left: A level logger data collection at one of the headwater sites.
Above: Lory Willard, John Gitonga and a team from the Water Resources Authority during a cross-section survey at OI Jogi.



Photos: Kevin Uno

John Gitonga teaches students the concept of cryogenic extraction of water from plants and soils for their research projects.

Water Isotopes in Central Kenya

By Kevin Uno
Division of Biology and Paleo Environment
Lamont-Doherty Earth Observatory of Columbia University

Introduction

The stable isotope ratios of hydrogen and oxygen in modern environmental waters record important information about atmosphere and ecosystem processes such as moisture transport, seasonality, and aridity (Gat, 1996; Li et al., 2017; Rozanski et al., 1996; Soderberg et al., 2013). Stable isotopes serve as natural tracers of fundamental hydrologic processes, but they also can be used to understand the ecology of plants and animals.

My colleagues and I have shown that oxygen and hydrogen isotopes in elephant tusks, teeth and hair record seasonal variability in an animal's physiology, diet, and behavior at weekly resolution and that this information can be used for conservation and management purposes (Cerling et al., 2009;

Uno et al., 2020a; Uno et al., 2020b). Water isotopes can also be used to understand aspects of plant physiology using water extracted from modern plant tissues. The hydrogen isotopes of plant waxes, which are preserved in the geologic record for millions, can similarly be used to study ecosystem aridity, plant physiology, or rainfall in the past (Sachse et al., 2012; Sachse et al., 2006). As an example, plant waxes in ancient sediments can be used study precipitation changes over evolutionary time scales in the East African Rift System.

To use isotopes as tracers in plants, animals, and at the ecosystem scale in modern and past ecosystems, we must first characterize their behavior in modern ecosystems where we can measure them in the environmental context of rainfall amount, temperature, elevation and other variables. The goal of this project is to understand how water isotopes in Central



Left: Students and staff preparing a dewar of liquid nitrogen to extract water from plants. **Right:** Students sample water from one of Mpala's reservoirs.

Kenya record hydrologic and other ecosystem processes so we can answer scientific questions about past, current, and future rainfall.

Past research at Mpala Research Centre (MRC) by Kelly Caylor's group (Li et al., 2017; Soderberg et al., 2013) helped establish a strong foundation for our new project and provided critical infrastructure for the newly established *Paleo- and Eco-hydrology Research at the Mpala Isotope Lab* (PERMILab). Our ongoing research at MRC and Samburu National Reserve (SNR) on plants and animals will benefit from new water sampling of local rivers, springs, and rainfall events. In addition to providing information about modern waters of Central Kenya today, the data will also be used to interpret output from an isotope-enabled climate model that will explore precipitation and ecosystem change in eastern Africa over the last ~25 million years. This modeling effort is part of a large, NSF-funded project called the Turkana Miocene Project, whose aim is to explore the role of climate and tectonics in mammalian evolution over the latest Oligocene and Miocene periods.

Continent-wide Sampling Program

Our water sampling campaign in Laikipia and Samburu counties fits within a larger, continental sampling effort. In collaboration with MRC research Liaison John Gitonga and other isotope geochemists and climate scientists from Stony Brook University and the University of Michigan, we have established a new water sampling program in Africa to measure water isotopes in surface waters and precipitation. Other sampling sites across Africa that we are working to include in the network are mostly at primate research or fossil localities at Lake Turkana, Kenya; Rusinga Island, Kenya; Issa, Tanzania; Gombe, Tanzania; Kokolopori, DRC; Goulougo, République du Congo; and Loango, Gabon. All water samples will be analyzed at the PERMILab at MRC.

Mount Kenya Catchment Sampling Program

John Gitonga and I have set up a regular (bi-weekly) water sampling of the Ewaso Ng'iro watershed from the highlands of Mt. Kenya through the Nanyuki urban corridor, into Mpala, and out to SNR (Figure 1). At the terminus of our sampling

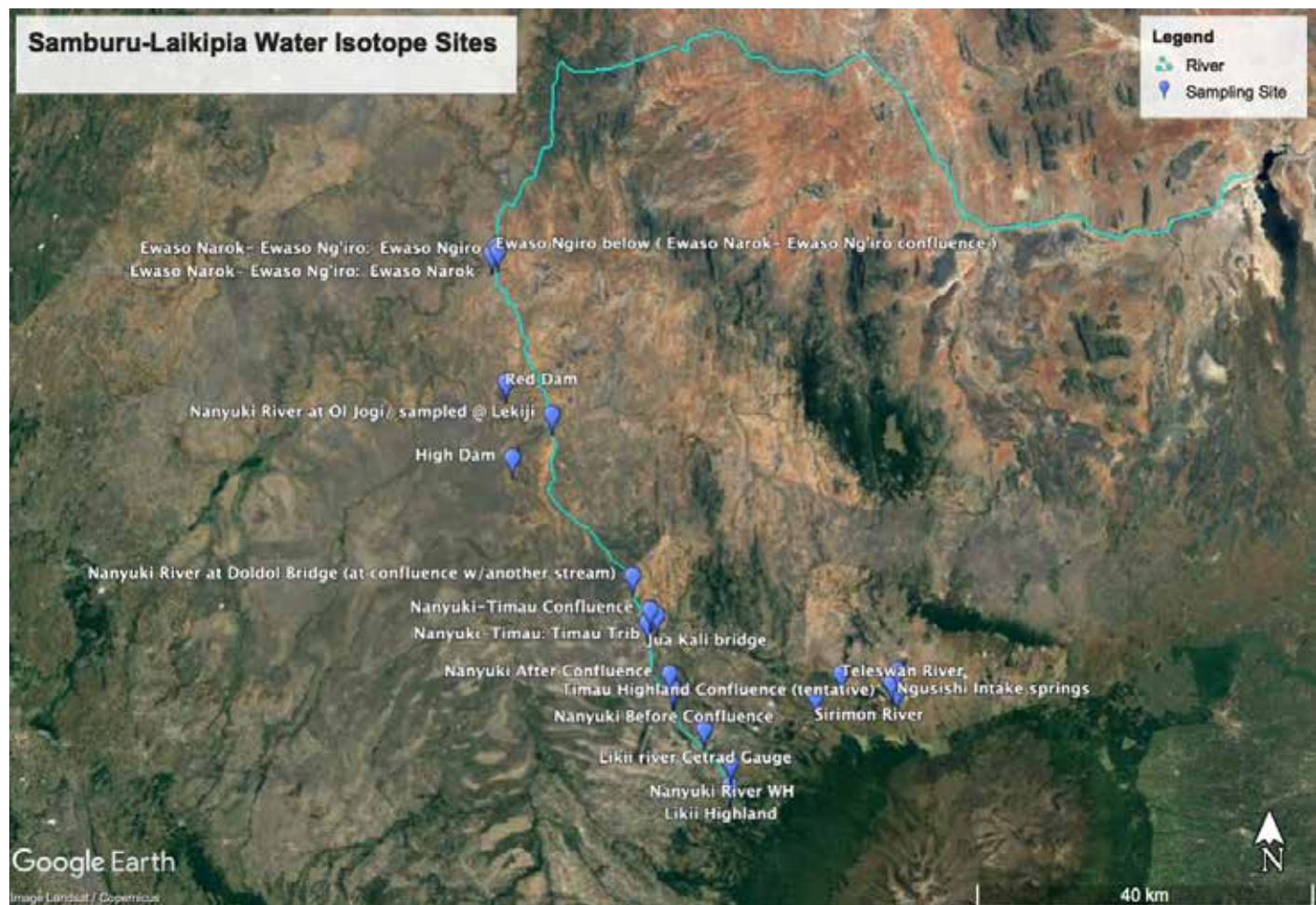


Figure 1. Sampling sites in Laikipia and Samburu Counties. Sampling is twice monthly for surface waters (blue markers) and precipitation is by event at MRC and soon, STE.

transect, colleagues at the Save the Elephants (STE) camp will assist in bi-weekly sampling. John Gitonga has built rainfall collectors so we can also measure stable isotope ratios of individual precipitation events. The collectors have been deployed at Mpala, at two sites up in the Turkana Basin, and will soon be set up in SNR at the STE camp. Water samples will be collected from the Turkana and SNR sites quarterly or semi-annually, brought back to the PERMILab at MRC and analyzed. We plan to train Kenyan scientists in isotope hydrology methods and the use of the PERMILab, which may include staff from MRC, STE, masters students from Turkana University College, and other organizations such as the Kenya Agricultural Research Institute (KARI), who also have a water isotope analyzer similar to the one in the PERMILab. KARI currently lacks the expertise to operate and maintain their analyzer so we plan to provide a multiday training workshop for them in fall of 2021.

Data from this project will be publicly available once published and will be available prior to publication to Mpala researchers

upon request. The project has already provided research opportunities for students in courses I teach a Mpala to be involved in data collection, analysis and interpretation.

Funding. This research is supported by two grants, an NSF CAREER grant (19-45446) active through 2025 and NSF FRES EAR 20-21666, active through 2024, to Kevin Uno. The PERMILab was established in 2018 from funds received from an NSF-DEB grant (18-21088) to Prof. Daniel Rubenstein and Mpala's Executive Director, Dr. Dino Martins.



Dr. Wilfred Odadi

Enhancing Co-existence of People, Livestock and Wildlife

By Dr. Wilfred Odadi

Dr. Wilfred Odadi from Egerton University working at Mpala is currently undertaking two projects.

The first project titled: ***Evaluating land sharing schemes between communal and private ranches, and grazing intensity effects on biodiversity and livestock in Laikipia, Kenya***

Dr. Odadi is analysing how land sharing schemes between pastoralists and private ranchers work, their ecological and social impacts, and challenges in their implementation in Laikipia landscape, Kenya. In addition, he is assessing how biodiversity and livestock respond to changing grazing intensity, with a view to determining the optimal grazing intensity levels for biodiversity conservation and livestock production in such landscapes.

The findings of this research will provide valuable tools for enhancing sustainable management of coexistence of wildlife, livestock and people, with desirable implications for Africa and its people. This is funded by The Royal Society, UK.

The second project titled: ***Evaluating the potential***

of intensive livestock grazing and coralling to enhance ecosystem services in Africa's communal rangelands

Dr. Odadi together with his collaborator, James Bennett from Coventry University, UK are quantifying the effectiveness of community-based intensive livestock grazing and coralling in enhancing ecosystem services in the communal rangelands of northern Kenya. Specifically they are measuring changes in vegetation, soil quality and wildlife and livestock use associated with livestock corral sites. Linked to this, they are also examining the capacity of existing local community institutions and governance structures to sustainably implement these community-based approaches over the longer term with minimal external support.

The research is expected to enhance the capacity of local pastoral communities to manage communal rangelands more sustainably, with desirable implications for biodiversity conservation, livestock productivity and livelihoods. This is funded by The Royal Society, UK and co-hosted by Egerton University and Coventry University UK.

MpalaLive!

By Valerie May -
Principal investigator/ Executive Producer,
MpalaLive!

Photos: MpalaLive!



Mpalalive.org is an educational digital outreach program focused on spreading the conservation message and inspiring a new generation of conservation biologists. It is supported by The Annenberg Foundation. We started the project in 2013 and launched the website in 2014. The core offering is live cams stationed at the “hippo pool.” These live feeds appear both on MpalaLive.org and on Annenberg’s Explore.org website.

The educational offerings on MpalaLive.org include an interactive **Field Guide** featuring 88 species (possibly the most complete resource for East African animals available online); **Stories from the Bush** with 39 archived live chats and short videos describing the research and wildlife of Mpala; a **Classroom** section featuring downloadable lesson plans and classroom activities geared to US and Kenyan students from grades 1 through 12; **Live Cams/ Best of Mpala** featuring 28 curated wildlife videos.

Despite the challenges presented by the pandemic, the MRC MpalaLive.org staff (our IT lead Joseph Irura, and camera operators Anne Mukoma, Fred Kiboko, and Everlyn Kimuli) maintained live cam operations.

The night vision and upgraded hi-def camera systems continue to provide great viewing and entertaining peeks into the nightlife or our wildlife.

In collaboration with Northern Kenya Conservation Clubs (NKCC) – we’ve added the Reading Corner to **Stories from the Bush**. These multimedia features engage children with active storytelling. We currently have 9 stories posted, each story chosen to inspire children with a love and understanding of the natural world. All of the stories connect back to the lessons and activities found at: <https://www.mpalalive.org/classroom>. In 2021 we also posted two videos describing the origin of the NKCC and their celebratory Community Conservation Day.



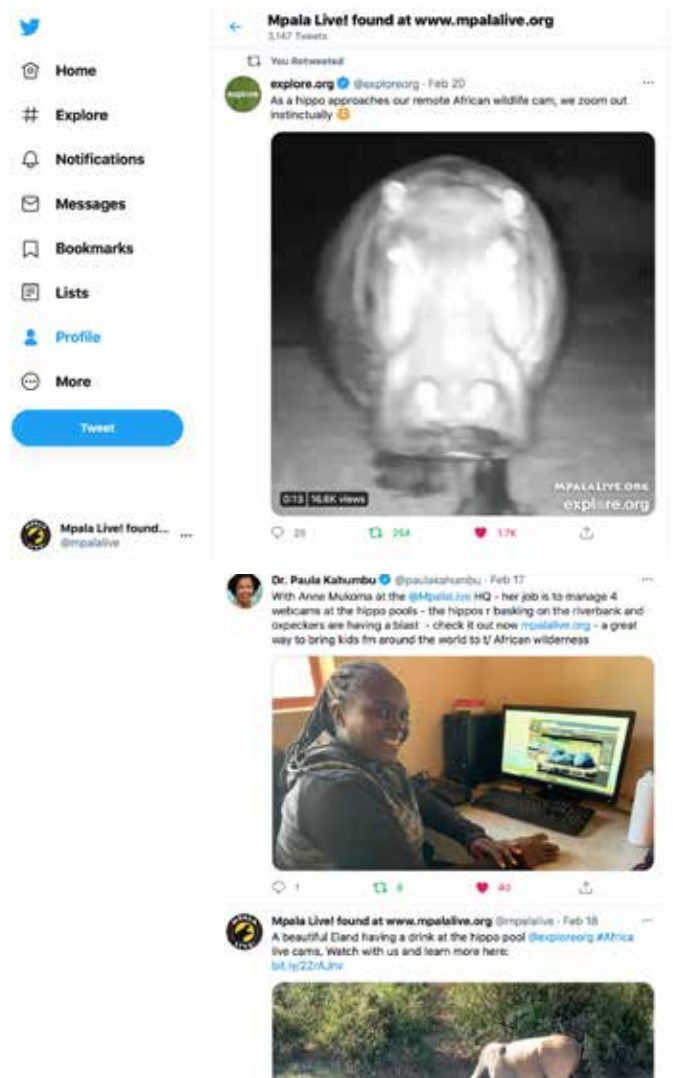
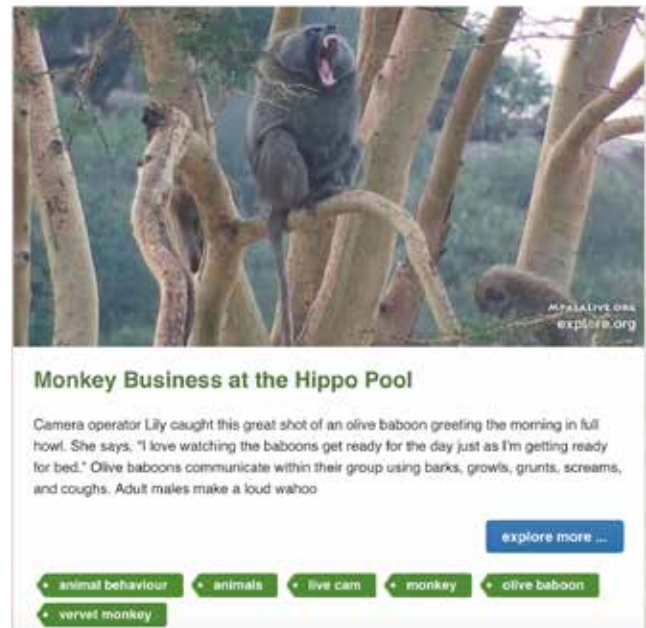
Traffic Statistics and Live Cams from January 1 to October 20, 2021

All the MpalaLive.org traffic data is **exclusive** of live cam views on Explore.org. The tracking data shows that we have a different consumer base from Explore. For this period we had 286,554 page views and 181,616 users—about 650 users per day. Our geographic distribution is quite different from Explore—26% from the US; 18% from India; 12% from the Philippines; 4% from the UK, with the rest of the traffic distributed around the globe. Further, 70% of the page views went to the **Classroom** section, underscoring the importance of virtual learning during this time.

Traffic to the live cams on Explore.org reached 2.95 million page views and 484,591 users. About 50 percent of the traffic to Explore.org is from the US—quite different from the stats we see for the MpalaLive.org site.

Social media

During this period the MpalaLive! team posted regularly to Twitter, Instagram, Facebook, the Explore blog and the Disqus live cam feed. There are currently 35,244 comments on the live cams Disqus board—approximately 3,500 per month.



Conservation Education Outreach

We work with Kenya's Institute for Curriculum Development to help spread the conservation message to the country's students. Although schools were closed from March through December of 2020, KICD broadcasted its curriculum via their TV EduChannel, an alternative in a country where more students have access to TV than computers. To help break up the hours of rote learning and familiarize students with their nation's amazing wildlife, MpalaLive.org content was interspersed between the lessons.

In an agreement signed in 2020, we had planned on producing two weekly shows with KICD for their EduChannel. We hope to resume that effort in 2022.

Next Steps

As we've moved into 2021 and a loosening of pandemic restrictions, we are resuming initiatives suspended last year. These include:

- Co-development with KICD of two EduChannel TV shows featuring the Explore.org live cam footage and conservation features and activities for children
- Development of "Virtual Classroom"—an online collaborative learning platform bringing together students from Kenya, the UK, and the USA—*in production*
- Expansion of the Field Guide with the addition of 25 bird species—*in production*
- Lesson plans and activities featuring the Explore.org live cams—*in production*

We are seeking assistance with the development of Virtual Classroom. We want to launch this initiative with at least three schools—one each from Kenya, Great Britain, and the US. Our plan is to have a soft launch with a handful of schools to beta test the project. If you know of any schools that might be interested please let us know (valeriemay1326@yahoo.com).



1 2
3 4





1. Grevy's zebra quenching thirst at the pool • 2. Leopard on hunting mode along the Ewaso Nyiro River • 3. Elephants with babies quenching thirst at hippo pool • 4. Lioness pair taking a nap at livecams • 5. Black crowned night heron hunting at the watering hole • 6. Hippo mum and two calves, one being a sub-adult • 7. Long-tailed cormorant • 8. Leopard tortoise • 9. White-browed coucal • 10. African fish eagle and its prey.



Community Connections

By Beatrice Wanjohi, Sheila Njoroge & Fardosa Hassan

School Feeding Program

On 19th March 2021, we distributed food items to 11 primary and 4 secondary schools. With the COVID-19 pandemic and failed rains, many families have been struggling with feeding. This was able to feed primary and secondary school candidates sitting national examinations in March. The schools supported are all part of the Northern Kenya Conservation Clubs (NKCC). They are:

Primary Schools

1. Lekiji Primary School
2. Shiloh Naibor primary
3. Olgirgir primary School
4. Reteti primary School
5. Il motiok primary School
6. Naiperere primary School
7. Ewaso primary School

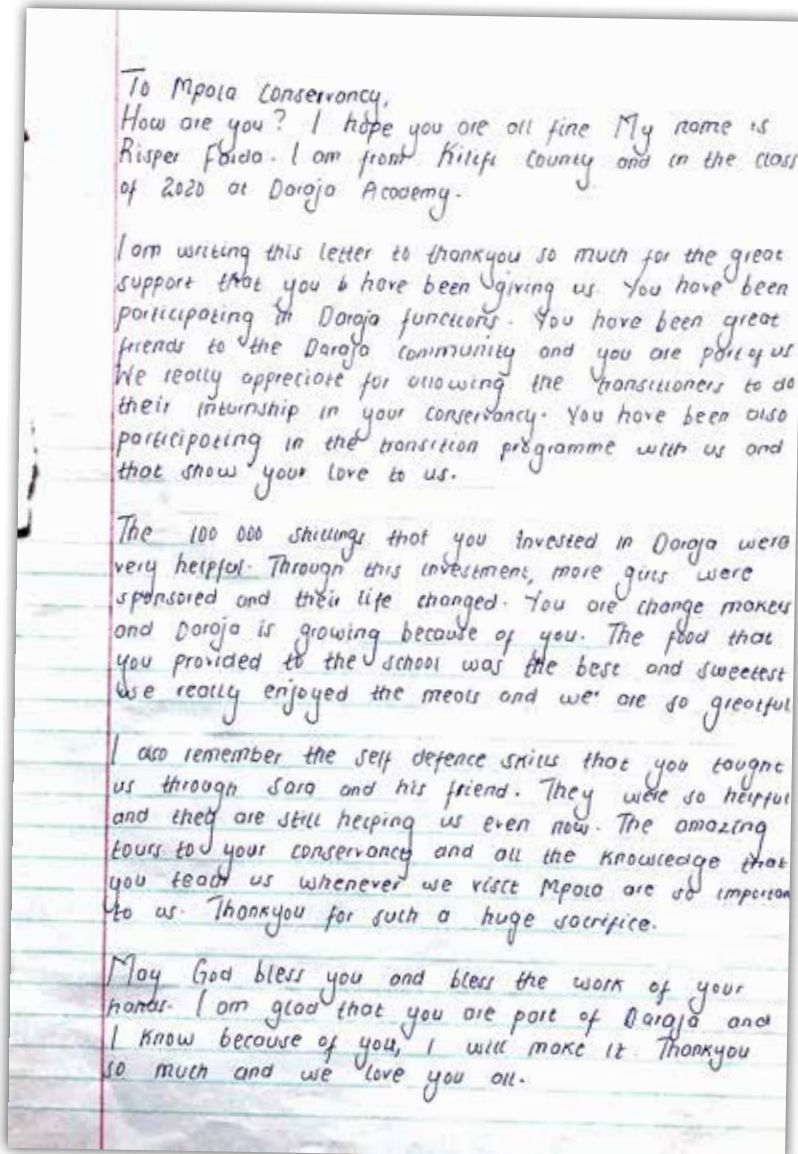
8. Kimanjo primary School
9. Nkiloriti primary School
10. Ng'abolo primary School
11. Musul primary School

Secondary Schools

1. Daraja Academy
2. Ewaso secondary School
3. Kimanjo secondary School
4. Naibor Secondary

In total 492 students were fed, 351 primary school students for the 4 examination days and 141 secondary students were fed for a month of examinations.

Below is a note of gratitude from the head teachers and students supported.



George Small Foundation

In 2021, the George Small Scholars support has continued with 16 students. We have had 3 finish High School:

1. Fatuma Maigwa (St Francis Girls Doldol) B
2. Mejaki Piyet (Doldol Boys) B-
3. Felister Lowoi (Naru Moro Girls) C

We expect two students in Vocational Training to complete their training later in the year.

We have enrolled 5 new students – 2 into Vocational training and 3 into High School. The selection was carried out by a GSF committee that reviewed applications from Lekiji, Il-Motiok group ranches and Mpala staff for their children. The following were the successful candidates;

High school awards

1. Fridah Nailopoje Il-Motiok

2. Matthew Koileken Lekiji
3. Vincent Mbarire Mpala Staff

Vocational Training

1. Agnes Namtoyi Il-Motiok
2. Emmanuel Erupe Lekiji

Daraja Academy

We have continued to engage with Daraja Academy. Staff and management joined the Daraja family to celebrate the excellent results of the candidates. The girls performed very well getting a mean grade of 8.13 out of 12 points.

On 6th July, the head of HR led a team of panellists to prepare girls for interviews before they embarked on community service, which is the preparation stage before joining college. The Daraja team expressed their gratitude for Mpala's continued support.



One More Day For Children

In May, we delivered food and sanitation supplies to One more day for children to support the rescued girls in the safe house who are out of school due to COVID-19. The Executive Director, Hellen Gathogo appreciated the support.



Mpala team with the visiting Kenyatta University students.

A day with students from Kenyatta University

On 19th of August we hosted third year students pursuing B.Sc degree in Animal Health and Management, from Kenyatta university under the department of Animal Science.

The educational tour aimed at demonstrating the roles and challenges a range manager in the century faces to ensure that they are able to produce livestock while conserving the rangelands sustainably. The students however gotten an opportunity to learn from other research projects that connected with their work as future livestock managers.

At the campus they visited our automated weather station, the DNA and isotopes laboratories and Mpala live. They also learnt Mpala's critical role through the annual rabies vaccination, in curbing the spread of the zoonotic to protect communities and conserve the wild dog population.

During the afternoon field session with Samuel and Kimani, they went to the (KLEE) Kenya Long-term Exclosure Experiment, existing and old boma sites. Here they experienced the interface of wildlife conservation and livestock production amongst other issues the challenges and opportunities in rangeland utilization, vegetation cover and soil types, invasive species and beef cattle production.

The group through their lecturer Dr. Mburu Leonard was very grateful to the Mpala community for this opportunity that complemented the student's class work while instilling hands-on knowledge and skills.

Lekiji Women Initiative

This year, Our Operations Assistant, Fardosa Hassan who is from Lekiji our neighbouring community was awarded a

funding by ABSA Bank. This was successful after she submitted her proposal to a call from ABSA celebrating their one-year anniversary.

This funding of KES 2.9M will support her initiative "beadwork for girls education" an initiative that aims to support women in her village through beadwork, and the main goal is to generate income to fund girls' education in Lekiji Village.

Out of 157 projects that were submitted only 4 were shortlisted and the beadwork idea was one of them. The public was invited to vote for the final two winning ideas and Lekiji Women Initiative emerged as the most loved initiative on the Wall of Possibilities competition by ABSA bank.

Majority of women in Lekiji Village are unemployed, and due to this, they've been mainly involved in the production of illicit brew commonly known as "changaa" and charcoal burning to be able to provide for their families. Through Fardosa's initiative on the beadwork program, women in Lekiji Village are now involved in productive income-generating activities, and money made from this venture allows them to sustain their families.

"One of our goals is to mentor and support young vulnerable girls in Lekiji village. A big percentage of the girls in Lekiji village don't get a chance to continue with their studies after primary school due to the high level of poverty in the village. We are working to end the challenges like teenage pregnancies and early marriages that the teenage girls in Lekiji community have been facing for so long. We believed that when girls are given tools, space, and encouragement, they are empowered to develop their voices in their communities and navigate the challenges they're facing"



Photos: Fardosa Hassan

Current Publication List 2021

- Beery, S. and Bondi, E., 2021. Can poachers find animals from public camera trap images?. arXiv preprint arXiv:2106.11236.
- Brody, A.K., Palmer, T.M., Fox-Dobbs, K. and Doak, D.F., 2010. Termites, vertebrate herbivores, and the fruiting success of *Acacia drepanolobium*. *Ecology*, 91(2), pp.399-407.
- Castillo Vardaro, J.A., Bonachela, J.A., Baker, C.C., Pinsky, M.L., Doak, D.F., Pringle, R.M. and Tarnita, C.E., 2021. Resource availability and heterogeneity shape the self-organisation of regular spatial patterning. *Ecology Letters*, 24(9), pp.1880-1891.
- Charles, G.K., Riginos, C., Veblen, K.E., Kimuyu, D.M. and Young, T.P., 2021. Termite mound cover and abundance respond to herbivore-mediated biotic changes in a Kenyan savanna. *Ecology and Evolution*, (preprint).
- Chen, A., Reperant, L., Fischhoff, I.R. and Rubenstein, D.I., 2021. Increased vigilance of plains zebras (*Equus quagga*) in response to more bush coverage in a Kenyan savanna. *Climate Change Ecology*, p.100001.
- Childers, R.A., 2021. Ecology and Evolution of the African Ant *Acacia*, *Vachellia drepanolobium*, and Its Multiple Symbionts (Doctoral dissertation, Harvard University).
- Comizzoli, P., Pagenkopp Lohan, K.M., Muletz-Wolz, C., Hassell, J. and Coyle, B., 2021. The interconnected health initiative: a Smithsonian framework to extend one health research and education. *Frontiers in Veterinary Science*, 8, p.255.
- Crego, R.D., Wells, H.B., Ndung'u, K.S., Evans, L., Nduguta, R.N., Chege, M.A., Brown, M.B., Ogutu, J.O., Ojwang, G.O., Fennessy, J. and O'Connor, D., Stacy-Dawes, J., Rubenstein, D. I., Martins, D. J., Leimgruber, P., & Stabach, J. A 2021. Moving through the mosaic: identifying critical linkage zones for large herbivores across a multiple-use African landscape. *Landscape Ecology* 36(5), pp.1325-1340.
- Dehnen, T., Papageorgiou, D., Nyaguthii, B., Cherono, W., Penndorf, J., Boogert, N.J. and Farine, D.R., 2021. Costs dictate strategic investment in dominance interactions. *bioRxiv* (preprint).
- Esmaeili, S., Jesmer, B.R., Albeke, S.E., Aikens, E.O., Schoenecker, K.A., King, S.R., Abrahms, B., Buuveibaatar, B., Beck, J.L., Boone, R.B. and Cagnacci, F., 2021. Body size and digestive system shape resource selection by ungulates: A cross-taxa test of the forage maturation hypothesis. *Ecology Letters*, 24(10), pp.2178-2191.
- Gitau, A.N., Onwonga, R.N., Mbau, J.S., Chepkemai, J. and Mureithi, S.M., 2021. Effect of Grazing Management and Land Cover Types on Mineral-Associated Organic Carbon and Particulate Organic Carbon in a Semi-arid Rangelands in Kenya. *Research Square* (preprint).
- Gold, S., Donnelly, C.A., Woodroffe, R. and Nouvellet, P., 2021. Modelling the influence of naturally acquired immunity from subclinical infection on outbreak dynamics and persistence of rabies in domestic dogs. *PLOS Neglected Tropical Diseases*, 15(7), p.e0009581.
- Grueter, C.C., Qi, X., Zinner, D., Bergman, T., Li, M., Xiang, Z., Zhu, P., Migliano, A.B., Miller, A., Krützen, M. and Fischer, J., 2020. Multilevel organisation of animal sociality. *Trends in Ecology & Evolution*, 35(9), pp.834-847.
- Guindre-Parker, S. and Rubenstein, D.R., 2021. Long-term measures of climate unpredictability shape the avian endocrine stress axis. *The American Naturalist*, 198(3), pp.394-405.
- Hannah, C., Giroux, S., Krell, N., Lopus, S.E., McCann, L.E., Zimmer, A., Caylor, K.K. and Evans, T.P., 2021. Has the vision of a gender quota rule been realized for community-based water management committees in Kenya?. *World Development*, 137, p.105154.
- Harel, R., Loftus, J.C. and Crofoot, M.C., 2021. Locomotor compromises maintain group cohesion in baboon troops on the move. *Proceedings of the Royal Society B*, 288(1955), p.20210839.
- Isbell, L.A., Bidner, L.R., Loftus, J.C., Kimuyu, D.M. and Young, T.P., 2021. Absentee owners and overlapping home ranges in a territorial species. *Behavioral Ecology and Sociobiology*, 75(1), pp.1-14.
- Kamau, M.W., Brown, J.L., Hassell, J.M., Gaymer, J., Farnham, M.W., Mutinda, M., Kariuki, L., Gakuya, F., Martins, D.J. and Murray, S., 2021. Establishing East Africa's first endocrinology laboratory to aid in wildlife conservation. *African Journal of Wildlife Research*, 51(1), pp.13-18.
- Kamau, M.W., Hassell, J.M., Milnes, E.L., Hayek, L.A.C., Mutinda, M.M., Harel, R., Matsumoto-Oda, A., Yu, J.H., Zimmerman, D., Crofoot, M. and Murray, S., 2021. Point of Care Blood Gas and Electrolyte Analysis in Anesthetized Olive Baboons (*Papio anubis*) in a Field Setting. *International Journal of Primatology*, pp.1-15.
- Kenfack, D., Arellano, G., Kibet, S., Kimuyu, D. and Musili, P., 2021. Understanding the monodominance of *Acacia drepanolobium* in East African savannas: insights from demographic data. *Trees*, pp.1-12.
- Kibet, S., Nyangito, M., MacOpiyo, L. and Kenfack, D., 2021. Savanna woody plants responses to mammalian herbivory and implications for management of livestock-wildlife landscape. *Ecological Solutions and Evidence*, 2(3), p.e12083.
- Kimuyu, D.M., Kenfack, D., Musili, P.M. and Ang'ila, R.O., 2021. Fine-scale habitat heterogeneity influences browsing damage by elephant and giraffe. *Biotropica*, 53(1), pp.86-96.
- Kirathe, J.N., Githaiga, J.M., Chira, R.M. and Rubenstein, D., 2021. Land use influence on distribution and abundance of herbivores in Samburu-Laikipia, Kenya. *Journal of Sustainability, Environment and Peace*, 4(1), pp.21-29.
- Klarevas-Irby, J.A., Wikelski, M. and Farine, D.R., 2021. Efficient movement strategies mitigate the energetic cost of dispersal. *Ecology Letters*. 2021 Jul;24(7):1432-1442.
- Krell, N.T., Giroux, S.A., Guido, Z., Hannah, C., Lopus, S.E., Caylor, K.K. and Evans, T.P., 2021. Smallholder farmers' use of mobile phone services in central Kenya. *Climate and Development*, 13(3), pp.215-227.
- LaMalfa, E.M., Riginos, C. and Veblen, K.E., 2021. Browsing wildlife and heavy grazing indirectly facilitate sapling recruitment in an East African savanna. *Ecological Applications*, p.e02399.
- Larison, B., Kaelin, C.B., Harrigan, R., Henegar, C., Rubenstein, D.I., Kamath, P., Aschenborn, O., Smith, T.B. and Barsh, G.S., 2021. Population structure, inbreeding and stripe pattern abnormalities in plains zebras. *Molecular Ecology*, 30(2), pp.379-390.
- Lea, A.J., Waigwa, C., Muhoya, B., Lotukoi, F., Peng, J., Henry, L., Abhyankar, V., Kamau, J., Martins, D., Gurven, M. and Ayroles, J.F., 2021. Social gradients in health vary between rural and urban Turkana. *medRxiv* (preprint).
- Liao, C., Agrawal, A., Clark, P.E., Levin, S.A. and Rubenstein, D.I., 2020. Landscape sustainability science in the drylands: mobility, rangelands and livelihoods. *Landscape Ecology*, pp.1-15.

- Martins, D.J., 2021. Best practice for protecting pollinators. *Nature Ecology & Evolution*, pp.1-2.
- Masika, S.J., Muchemi, G.M., Kamau, J.M., Abuom, T. and Mutura, S.K., 2021. Molecular detection of *Anaplasma phagocytophilum* DNA in Olive Baboons and Vervet monkeys in Kenya. *Research Square* (preprint).
- Merid, N., Peter, A., John, N., Abel, O., Daniel, M. and Baldwyn, T., 2021. Shared volatile organic compounds between camel metabolic products elicits strong *Stomoxys calcitrans* attraction. *Scientific Reports*, 10(1), 1–14.
- Milligan, P. D., T. A Martin, E. G. Pringle, C. Riginos, G. M. Mizell, and T. M. Palmer. A soil-nesting invasive ant disrupts carbon dynamics in saplings of a foundational ant-plant. *Journal of Ecology*. In press.
- Milligan, P.D., Martin, T.A., John, G.P., Riginos, C., Goheen, J.R., Carpenter, S.M. and Palmer, T.M., 2021. Mutualism disruption by an invasive ant reduces carbon fixation for a foundational East African ant-plant. *Ecology Letters*, 24(5), pp.1052-1062.
- Milner, J.E., Blackwell, P.G. and Niu, M., 2021. Modelling and inference for the movement of interacting animals. *Methods in Ecology and Evolution*, 12(1), pp.54-69.
- Ngatia, D.K., Webala, P.W., Mware, M.J., Butynski, T.M., de Jong, Y.A. and Ferguson, A.W., 2021. Biogeography of the Egyptian mongoose *Herpestes ichneumon* (Linnaeus, 1758) in Africa, with first records for Laikipia County, central Kenya. *African Journal of Ecology*. 2021; 59: 359– 369.
- Oburah, K.O., Lenachuru, C. and Odadi, W.O., 2021. Does the Community Conservancy Model Work for Pastoralists? Insights from Naibunga Conservancy in Northern Kenya. *Sustainability*, 13(14), p.7772.
- Papageorgiou, D., Rozen-Rechels, D., Nyaguthii, B. and Farine, D.R., 2021. Seasonality impacts collective movements in a wild groupliving bird. *Movement Ecology*, 9(1), pp.1-12.
- Patel, J., Katan, J., Perez, L. and Sengupta, R., 2021. Transferring decision boundaries onto a geographic space: Agent rules extracted from movement data using classification trees. *Transactions in GIS*, 25(3), pp.1176-1192.
- Pietrek, A.G., Goheen, J.R., Riginos, C., Maiyo, N.J. and Palmer, T.M., 2021. Density dependence and the spread of invasive bigheaded ants (*Pheidole megacephala*) in an East African savanna. *Oecologia*, 195(3), pp.667-676.
- Rajeshwari, K., Hegde, A.R. and Patil, D., 2021, August. Students' Perception and Reconciliation: Decision Making in Project Groups Formation. In *Journal of Physics: Conference Series* (Vol. 2007, No. 1, p. 012004). IOP Publishing.
- Reinwald, M., Moseley, B., Szenicer, A., Nissen-Meyer, T., Oduor, S., Vollrath, F., Markham, A. and Mortimer, B., 2021. Seismic localization of elephant rumbles as a monitoring approach. *Journal of the Royal Society Interface*, 18(180), p.20210264.
- Rhodes, A.C., Plowes, R.M., Goolsby, J.A., Gaskin, J.F., Musyoka, B., Calatayud, P.A., Cristofaro, M., Grahmann, E.D., Martins, D.J. and Gilbert, L.E., 2021. The dilemma of Guinea grass (*Megathyrsus maximus*): a valued pasture grass and a highly invasive species. *Biological Invasions*, pp.1-17.
- Rubenstein, D.R., Corvelo, A., MacManes, M.D., Maia, R., Narzisi, G., Rousaki, A., Vandenabeele, P., Shawkey, M. and Solomon, J., 2021. Feather Gene Expression Elucidates the Developmental Basis of Plumage Iridescence in African Starlings. *Journal of Heredity*, 112(5), pp.417–429.
- Seligsohn, D., Younan, M., Larsen, T., Morrell, J.M., Chenais, E. and Nyman, A.K., 2021. Detection of subclinical mastitis in camels (*Camelus dromedarius*) using somatic cell count, N-acetyl- β -D-glucosaminidase and lactate dehydrogenase activity. *Small Ruminant Research*, p.106512.
- Shah, S. and Rubenstein, D.R., 2021. Prenatal environmental conditions underlie alternative reproductive tactics that drive the formation of a mixed-kin cooperative society. *bioRxiv* (preprint).
- Sitters, J. and Olde Venterink, H., 2021. Herbivore dung stoichiometry drives competition between savanna trees and grasses. *Journal of Ecology*, 109(5), pp.2095-2106.
- Snider, M.H., Athreya, V.R., Balme, G.A., Bidner, L.R., Farhadinia, M.S., Fattebert, J., Gompper, M.E., Gubbi, S., Hunter, L.T., Isbell, L.A. and Macdonald, D.W., 2021. Home range variation in leopards living across the human density gradient. *Journal of Mammalogy*, 102(4), pp.1138-1148.
- Suire, A., Isbell, L.A., Bidner, L.R., Shinoda, Y., Akasaka, M. and Matsumoto-Oda, A., 2021. Influence of rainfall on sleeping site choice by a group of anubis baboons (*Papio anubis*). *American Journal of Primatology*, 83(1), p.e23223.
- Tawich, S.K., Bargul, J.L., Masiga, D. and Getahun, M.N., 2021. Supplementing Blood Diet With Plant Nectar Enhances Egg Fertility in *Stomoxys calcitrans*. *Frontiers in Physiology*, 12.
- Tchouassi, D.P., Torto, B., Sang, R., Riginos, C. and Ezenwa, V.O., 2021. Large herbivore loss has complex effects on mosquito ecology and vector-borne disease risk. *Transboundary and Emerging Diseases*, 68(4), pp.2503-2513.
- Titcomb, G., Mantas, J., Hulke, J., Rodriguez, I., Branch, D. and Young, H., 2021. Water sources aggregate parasites, with increasing effects in more arid conditions. *Research Square* (preprint)
- Titcomb, G.C., Amooni, G., Mantas, J.N. and Young, H.S., 2021. The effects of herbivore aggregations at water sources on savanna plants differ across soil and climate gradients. *Ecological Applications*, p.e02422.
- Tombak, K.J., Budischak, S.A., Hauck, S., Martinez, L.A. and Rubenstein, D.I., 2020. The non-invasive measurement of faecal immunoglobulin in African equids. *International Journal for Parasitology: Parasites and Wildlife*, 12, pp.105-112.
- Wells, H.B., Crego, R.D., Opedal, Ø.H., Khasoha, L.M., Alston, J.M., Reed, C.G., Weiner, S., Kurukura, S., Hassan, A.A., Namoni, M. and Ekadeli, J., 2021. Experimental evidence that effects of megaherbivores on mesoherbivore space use are influenced by species' traits. *Journal of Animal Ecology*, 90(11), pp.2510-2522.
- Wells, H.B., Kimuyu, D.M., Odadi, W.O., Dougill, A.J., Stringer, L.C. and Young, T.P., 2021. Wild and domestic savanna herbivores increase smaller vertebrate diversity, but less than additively. *Journal of Applied Ecology*, 58(5), pp.953-963.
- Wells, H.B., Kimuyu, D.M., Odadi, W.O., Dougill, A.J., Stringer, L.C. and Young, T.P., 2021. Wild and domestic savanna herbivores increase smaller vertebrate diversity, but less than additively. *Journal of Applied Ecology*, 58(5), pp.953-963.
- Werner, C.M., LaMalfa, E., Sensenig, R.L., Kimuyu, D., Veblen, K.E. and Young, T.P., 2021. Synergistic effects of herbivores and repeat fire on spatial heterogeneity of prescribed burns and their consequences for tree saplings. *Ecology* 102(4).
- Young, T.P., Kimuyu, D.M., Odadi, W.O., Wells, H.B. and Wolf, A.A., 2021. Naïve plant communities and individuals may initially suffer in the face of reintroduced megafauna: An experimental exploration of rewilding from an African savanna rangeland. *PLOS One*, 16(4), p.e0248855.

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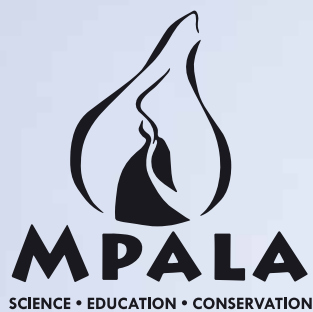
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