Final Evaluation Report

Your Details	
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Project Title	Testing invasive ant removal and environmental recovery on two conservancies in the Kenyan Laikipia Plateau
Application ID	25478-1
Grant Amount	£5999
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1. Indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.

Objective	Not achieved	Partially achieved	Fully achieved	Comments
How does biological invasion change the native insect community?				In our first set of feeding trials, conducted at 14 sites across two conservancies, we noted significantly fewer native ant species with reduced abundance. Further insect diversity surveys were discontinued due to PI evacuation from/lockdown in Kenya.
Does ant invasion also affect ecological functions provided by important native insect species?				Long-term monitoring stations were built at all 14 sites (termite monitoring blocks, seed removal pans), but the PI was forced to evacuate to the US due to COVID travel restrictions and the co-PI's movement was strongly limited for >3 months, making station maintenance impossible.
Can we effectively remove invasive ants using a method recently developed in the Western USA, and do native insects return to the previously invaded savannas?				In late 2019 while awaiting final government approvals, we developed a bait that was more effective at attracting invasive ants and also less attractive to native ants and was sourced from local materials at <5% of the original budgeted material costs. While we had already bought expensive hydrophilic beads as proposed, this alternative bait will make invasive ant removal far more affordable for local farms, ranches, and conservancies in the region.

2. Please explain any unforeseen difficulties that arose during the project and how these were tackled.

We encountered two major unforeseen difficulties: extremely stringent and slow-moving oversight by the Kenyan NEMA bureau and COVID-19-related interruption. Unfortunately, only the first difficulty was solved as both PIs were forced to discontinue the project in March 2020 after *ca*. 3 months of fieldwork and 8 weeks of experimental treatments.

We did have considerable success in cultivating relationships with NEMA officials and with research/conservation managers at both Mpala and Ol Pejeta Conservancies, which will allow us to take productive steps in the future if we are able to continue the research. Shortly after receiving our funding from Rufford, our project's research permit was suspended by Kenya's National Commission of Science, Technology, and Innovation (NACOSTI) in August 2019 pending further review of potential environmental impacts. Immediately, we hired an independent contractor that regularly works with NEMA to write a preliminary environmental impact assessment report for NEMA advisors, which was necessary before we could regain our permits and begin invasive ant removal trials. The contractors described known negative impacts of big-headed ant invasion in Laikipia savannas, and also collected survey responses from pastoralists and support staff living at/near both conservancies. Their surveys indicated strong approval for an effective removal tool but concern for non-target effects on native wildlife like bees and birds. Copies of the report have been distributed to NEMA and other Kenyan government agencies endorsing the project, and we were able to proceed with full support from NEMA, our conservancy partners, and the Kenya Wildlife Service in December 2019. We paid for this contractor out of my savings, not from funds provided by the Rufford Foundation, as this had not been an expense included in our original budget. However, the established relationships will be invaluable assets if we are able to restart this project in the future.

We proceeded with our insecticide bait trials at Ol Pejeta and Mpala Conservancies in January 2020, and we conducted 6 weeks of bait applications before we were forced to discontinue the project due to the COVID-19 pandemic. In March 2020, the rest of my research group evacuated Kenya and I originally planned to stay behind and continue the work. However, I was strongly advised by my department chair at the University of Florida to evacuate before Kenya shut its borders at the end of March 2020, and I followed her advice because support from the university was not guaranteed if I chose to remain in Kenya. Unfortunately, my co-PI Ivy Ng'iru was also unable to maintain the project on her own. While this was an insurmountable challenge at the time, it did cause Ivy and me to think about how we should restructure future efforts to do this research so that it would be resilient to this kind of public health emergency. Going forward, we plan for Ivy to take the lead role as manager of the field experiment and sample collection, while I would serve in a co-PI role to advise and provide logistical support.

3. Briefly describe the three most important outcomes of your project.

Because of the unexpected evacuation and premature end to the experiment, we were unable to achieve the original expected outcomes of the project. However, we did succeed in laying some foundations for future research by building partnerships with government agencies, establishing support from the local communities, and refining our ant removal baits to be more affordable for local partners and possibly have fewer adverse effects on native species.

As described above, our work with NEMA contractors was not anticipated in our original proposal but did help us to establish a productive relationship with Kenyan government agencies and with resident communities at Ol Pejeta and Mpala

conservancies. We received approval from NEMA for an initial research period of 2 years, with further approval possible pending submission of a final report after 2 years. When the pandemic began, NEMA confirmed via our contractor that the 2-year period could be postponed until we were able to restart the work after lockdowns were eased. Research directors at both conservancies, Dr. Dino Martins and Dr. Samuel Mutisya, have continued to express keen interest in continuing research on the invasive ant removals.

While we were awaiting our permit review by NACOSTI in late 2019, my co-PI and I tested various food baits to figure out how we could most effectively target invasive big-headed ants with insecticide while avoiding killing native insects, which was a major concern highlighted by the NEMA report. More specifics are given in response to question 4, but in short summary: we tested a bait composed of locally sourced ingredients against the bait designed by an invasive ant removal experiment in California, USA, and we found that the locally sourced bait better attracted invasive ants, did not often attract native ant species, and cost ~95% less than the imported bait. That news was especially heartening to our local partners, who were concerned about their ability to afford ant removals for large tracts of invaded conservancy land.

4. What do you consider to be the most significant achievement of this work?

As stated above, our most significant achievement is certainly the development of a bait for removing invasive ants that narrowly targets the invasive ants without targeting many native insects, and with no expected effects beyond insects. While we had originally proposed to use a hydrophobic polyacrylamide bead soaked in insecticide-laced sugar water, we found that bait to be quite attractive to native ant species and an ineffective attractant for big-headed ants. This was surprising, as the polyacrylamide bait was very attractive to other invasive ants with similar biology in other ecosystems. We eventually found that animal-feed-grade split corn soaked in soybean oil was extremely attractive to big-headed ants, but also not attractive to native insects. I consulted with an analytical chemist to figure out how to incorporate our water-soluble insecticide into this oil-based bait, but we were unable to collect data on its effectiveness before evacuation. However, we were very excited to find a bait that was both highly specific to big-headed ants and yet only cost about 5% as much as our original proposed bait. All the ingredients that we used to make this new bait technology – split corn, soybean oil, thiamethoxam, and water – can be easily purchased in large quantities from local agricultural and veterinary suppliers, and the treatment can be applied for $3-5 per ha per treatment, instead of ~$100 per ha as originally proposed.

5. Briefly describe the involvement of local communities and how they have benefitted from the project.

Our involvement with local communities was limited to their initial input into our contractor's report to NEMA, though we did record strong support for the project in our community surveys. Virtually all the residents at both conservancies suffer from this invasive ant which often raids food pantries, can attack chicken hatchlings, damages electrical wiring, and damages crop roots. Many residents were also

concerned that the invasive ants kill many native insect species that are important for habitat conservation and function. We had planned to lead weekend workshops with staff villages at Mpala and Ol Pejeta to provide ready-made baits and to help devise an application schedule, but we were not able to collect the necessary data to inform those workshops before evacuation.

6. Are there any plans to continue this work?

Co-PI Ivy Ng'iru is keenly interested in continuing this work in the main PI role as the research project for her planned PhD. She is currently interviewing with advisors at various universities in the UK. While in lockdown during the pandemic, I finished my PhD and graduated from University of Florida, so I am not eligible to continue working as a PI with affiliation to my past university. We also recognise that we can safeguard the project against future lockdowns of this nature if we place more responsibilities with local PIs and do not assign critical roles to international researchers that can be recalled. I am firmly committed to supporting Ms. Ng'iru as she pursues our original research goals. I am now working in the same region of Kenya as a postdoc for the University of Nevada, Reno, studying carbon allocation and epigenetics of *Acacia drepanolobium*, and I saved all our research materials so that Ms. Ng'iru can use them in the future.

7. How do you plan to share the results of your work with others?

Unfortunately, our pilot results were only intended as proofs of concept, and I would not expect them to be publishable in a peer-reviewed scientific journal. However, we may be able to publish a brief report on the relative attractiveness of various bait types that we tested at both conservancies in an invasive species management trade journal. If we can secure additional funding to continue this research, then we will likely incorporate those pilot data into a larger publication that would include insect diversity and ecosystem function data from longer-term monitoring efforts. If we are able to conduct a full field test of this technology in Laikipia, we will also draft a short handbook to distribute to interested conservancy managers who are interested in removing big-headed ants from their properties.

8. Timescale: Over what period was the grant used? How does this compare to the anticipated or actual length of the project?

We used the grant from September 2019-March 2020. We were waiting for permit review until the end of 2019, so I expect that we would have continued to use the grant until July 2020 per our proposed 7-month timeline, but we discontinued the project and ceased using grant funds at the end of March 2020.

9. Budget: Provide a breakdown of budgeted versus actual expenditure and the reasons for any differences. All figures should be in £ sterling, indicating the local exchange rate used. It is important that you retain the management accounts and all paid invoices relating to the project for at least 2 years as these may be required for inspection at our discretion.

Item	Budgeted Amount	Actual Amount	Difference	Comments
Indirect Costs collected by UF Research Office	1238	1104	-134	
Seed pans (for monitoring stations	112		-112	
Field lunches	281	189	-92	While our fieldwork was delayed by permit reviews, we did use fieldwork lunch funds to supply lunches when meeting with local community members for our NEMA report.
Additional luggage fees to transport hygroscopic beads	316	145	-171	Airline fees for a massively overweight bag were far more reasonable than shipping our beads via cargo freight.
Airfare	822	653	-169	
Classroom materials	230		-230	
Lumber for termite activity baits and roofing nails to find them in the future with a metal detector	69	18	-51	Only a small portion of our planned termite monitoring blocks were deployed
Toilet rolls	181		-181	
Materials for vertebrate exclusion cages	593		-593	
Lodging (October, January-March 2020)	1581	1350	-231	I submitted rent for October 2019 because nearly the entire month was spent conducting community surveys and meeting with NEMA representatives on behalf of the project, then I again reported rent for Jan-Mar when fieldwork had begun.

Thiamethoxam	149	177	+28	An initial 148.00 was spent on thiamethoxam from a US source, but we then found a cheap bulk supplier in Nanyuki, Kenya, at a fraction of the price (*ca*. 21.00 for enough chemicals for multiple years of experiments). I decided to buy from this supplier in anticipation of a long-term project.
Ant baits raw materials (corn, oil) Ant baits materials (hygroscopic beads)	427	432	+6	We went slightly over budget to source the experimental new bait that we developed while our permit was being reviewed in late 2019.
99.9% ethanol for insect sample preservation, sterile containers for storage		43	+43	We never exhausted our first supply of ethanol and storage containers because of our premature evacuation
Totals	**5999**	**4111**	**-1888**	Additional funds for student outreach, possible vehicle repairs, etc., were not used but were originally budgeted.
Note: UF Research Office reports an unspent account of USD4310 (GBP 3118) to be returned to Rufford Foundation. All the expenses that I report above were submitted to University of Florida Research Office for reimbursement and I received a complete compensation for them, though I honestly am unsure if part of my reimbursement was made with funds released by the state government for COVID emergency responses. They may also have forgotten to subtract indirect costs from the grant, which would account for much of the discrepancy. I was unaware of any discrepancy until July 2021, long after leaving UF. This is the only reasonable explanation I can provide for the large sum to be returned to Rufford, because by my calculations there should be ~GBP 1500 remaining from the grant. Of course, I am happy to provide proof of expenses for anything on this list. Apologies for any confusion caused here. (Converted at 1 KES to 0.0075 Pound sterling; ca. January 2020)				

10. Looking ahead, what do you feel are the important next steps?

We have now designed an ant bait that is far better tailored to this environment and to the invasive ant species in question than the baits developed by teams in western USA studying a different invasive ant species. Our next step is to field-test this bait with a range of insecticide concentrations to determine the minimum effective dosage, and to monitor the insect community before and after application to determine if the community can recover and assume functional niches that are reduced in invaded areas. These are essentially our original proposed goals. However, we now have strong government and conservancy partnerships in place to support future iterations of this project, and more cost-effective bait technology

that will allow us to draft budgets that can focus less on material costs and more on community outreach, local employee support, and development and training for co-PI Ivy Ng'iru. Future work will devise more comprehensive plans to involve local stakeholders to test our invasive ant removal technology in both conservancy areas and in villages and pastoralist households.

11. Did you use The Rufford Foundation logo in any materials produced in relation to this project? Did the Foundation receive any publicity during the course of your work?

No, we were planning to conduct more outreach and education events after we had collected sufficient data to validate our methods, but we did not use the Rufford Foundation logos during our NEMA report outreach or during our fieldwork in January-March 2020.

While working at Ol Pejeta in February 2020, I was interviewed by a documentary team that was producing a series for Ol Pejeta Conservancy titled "Secret Safari". I made clear in my conversations with their producer that my work was funded by Rufford. I was filmed during one of our insecticide treatment applications, but I was disappointed in two key points by the final version of scenes that were eventually aired on Channel 4 in the UK: 1) I made hypothetical statements about "what a success would look like" for our project that were edited to sound as if we had already achieved those goals, and 2) all of my affiliations with University of Florida and Rufford were not acknowledged and I was simply referred to as a "scientist at Ol Pejeta". I was naïve about how my statements and work would be represented on screen, and I did not consider how it might be edited to better fit a television narrative. I did not follow up with the producers because their work was cut short by the pandemic as well, and I assumed that the series was cancelled when they never reached out about checking the scientific accuracy of the final product. I can provide links to the documentary if Rufford Foundation representatives would like to review it.

12. Please provide a full list of all the members of your team and briefly what was their role in the project.

Patrick Milligan – PI. Managed all aspects of the field project including ant bait dispersals, insect pitfall trapping, termite wood bait deployment, and field material preparations. Primary contact for all meetings with NEMA and NACOSTI representatives.

Ivy Ng'iru – co-PI. Consulted with PI on insect bait design ideas from October-December 2019. Contributed to site selection at Mpala Conservancy. Advised on insect survey methods from January-March 2020. Planned to lead insect identification efforts, including identification of functional roles, in June 2020 (cancelled due to pandemic).

13. Any other comments?

I can frankly recognise this is a disappointing conclusion to our project. This is the only project that I have undertaken that has failed to deliver peer-reviewed scientific reports and outreach media, yet it was also the project that I felt had the most potential to benefit conservation in Laikipia out of any of my past research. So, I feel that I have failed on multiple fronts, for both scientific progress and for community capacity-building, and I hope that our work is not judged too harshly in light of the unusual conditions that we found ourselves in. I also would highlight that the few takeaway points that we could salvage from the project will inform Ms Ng'iru's future graduate research and will allow her to make a substantial impact on habitat conservation in Laikipia. If it is not out of line to suggest, I strongly endorse her to take over this research as head PI and to see it through to its completion. If it is possible to hand over the responsibilities to her for future grant applications, I will gladly do anything necessary to make that happen.

Figure 1. Top left) Selection of bait prototypes from left: sugar-water-soaked hygroscopic beads, oil-soaked millet, 1:1 peanut butter mixed with soybean oil, oil-soaked split corn. Top right) example of bait feeding trials 10 cm from big-headed ant nest at Mpala Conservancy. Bottom right) example of camouflage to prevent bait disturbance by primates and to shade the bait tubes. Bottom left) bait tubes were collected 8-10 hours after deployment, and caps were immediately screwed onto the top to trap any foraging ants. Tubes were then frozen to euthanize ants,

then ants were counted in each tube to determine relative attractiveness of each bait.

Note: this is a re-enactment of our bait attraction test protocol. Only one bait type/vial was used per mound to prevent interference between bait types. Pictured at top right are the original proposed bait (hygroscopic beads, L) and the new bait type that we developed (cracked corn and oil, R). Full resolution images are available in the original email to Jane Raymond with this report.

Figure 2. PI Patrick Milligan meets with environmental impact consultant Margaret Wanjiku Kariuki, representative for the National Environmental Management Authority of Kenya. Patrick is indicating a big-headed ant (*Pheidole megacephala*) nest at a study site in Ol Pejeta Conservancy: this invasive ant species has wiped out many native ant species at the conservancy, including native ants that would typically protect the whistling acacia trees (*Acacia drepanolobium*) that are a key part of black rhinoceros habitat. The whistling acacia in the foreground has been catastrophically damaged by herbivores after its native ant partners, which normally limit this damage to a manageable level, were killed by big-headed ants.