Hugo JEANNELLE
Student number: 22107546
Academic year: 2022 / 2023

Master 2 Ecology, Monitoring and Management of Ecosystems

Report of internship completed at: Ebony Forest Nature Reserve

Improving the efficiency of the control strategy for the small Indian mongoose (*Herpestes auropunctatus*) in Ebony Forest reserve, Mauritius.

Supervisor: Dr. Nicolas Zuël

University tutor: Dr. Frédéric Gimbert

The content of this dissertation is the sole responsibility of the candidate and the host organization and does not engage the scientific responsibility of the tutor and the university

Acknowledgements

I thank my internship supervisor Dr. Nicolas Zuël for his guidance and encouragement throughout every step of this project. I also thank my university tutor Dr. Frédéric Gimbert for his advice regarding the difficulties I have encountered with my fieldwork data collection. I would like to thank Pauline Marceau and other administrative staff from the Franche-Comté university, for their assistance that helped me getting an Erasmus + mundus scholarship, and to Bourgogne-Franche-Comté region for providing me with a "Dynastage" mobility scholarship. I would also like to express my appreciation to Kentish Bundhoo and all other members of the conservation staff at Ebony Forest for their advice and help on technical aspects, as well as for the quality of the professional experience I was able to have at their side. I also need to warmly thank Stéphane Mariam Pillai, Kasia Kalka, Loïc Robben, Victor Cadet and the other volunteers and interns at Ebony Forest who have helped me in my fieldwork.

Table of contents

1. Introduction

Oceanic islands: biodiversity hotspots, threats to native biota and necessity to control introduced predators

Oceanic islands that are formed via submarine volcanic activity, harbor ecosystems with native species that have never been connected to continent populations throughout their evolutionary history, after the original populations have dispersed to the islands (Whittaker R.J, Fernandez-Palacios J.M, 2007). Insular ecosystems thus often show high levels of endemism. Many of these oceanic islands are in what are commonly called “biodiversity hotspots”: encompassing 44% of all species of vascular plants and 35% of vertebrate species on 1.4% of the world's total land surface. These hotspots harbor numerous endemic species in confined areas while suffering from increasing habitat loss, making them areas of high level of priority to allocate restricted funding for conservation actions (Myers et al., 2000).

Invasive alien species are known to be the main threat on insular ecosystems, because of their key role in disproportionately rapid biodiversity losses and ecosystem perturbations on islands (Lever, 1994; Williamson, 1996; Spatz et al., 2017)). Among these invasive alien species, mammalian predators and especially rodents have the greatest adverse impacts on island biota; insular ecosystems often having very few or no natural predators, and native prey species thus often lacking anti-predator behavior (Blumstein and Daniel, 2005). Predation by these introduced mammals have led to dramatic rates of extinction of island native species, along with other issues such as agricultural damages and disease propagation (Williamson M., 1981). It has for instance been responsible for 42% of island bird extinctions in the past; rats, cats and mongooses being the most responsible for these extinctions (Ebenhard, 1988). Mammalian predators still constitute a major threat on 40% of island bird species (King, 1985). It has urged conservationists to develop different management techniques to deal with these introduced mammals, the most efficient way being a full eradication of those species from islands. Eradicating invasive mammals, and especially rodents, is now a widespread conservation goal on oceanic islands (Nogales et al., 2004) among which New-Zealand conservationists are leading the way. It is the most effective way to deal with introduced pests, once prevention has failed and these species have become well established outside of their native range, compared to permanent control or “do-nothing” policy, considering associated costs and benefits (Genovesi, 2007). The eradication of introduced mammals is therefore a powerful and cost-effective way of preventing further extinctions of threatened species: predator removal notably being consistent at enhancing bird post-breeding populations (Côté and Sutherland, 1997), while helping to restore native ecosystems on islands. It is however very difficult and costly to successfully carry out on the whole surface of an island. It is especially the case for large and inhabited islands which also involves gaining social acceptance from the local population and has appeared to exclusively be feasible on small and or uninhabited islands so far (Glen et al., 2013). Controlling mammalian predator populations to mitigate their impact on native biota is therefore often a more realistically achievable objective. Several different techniques are routinely used to eradicate or control mammalian predators on islands. For instance, the most used method to eradicate rats is the use of rodenticides such as Brodifacoum (Howald et al., 2007) and trapping to control their populations. Combination of trapping and hunting has also appeared to be successful in eradicating feral cats on small islands (Nogales et al., 2004). Multi predator species control is also crucial to take into account to successfully achieve conservation goals, considering trophic perturbations induced by the sudden removal of one predator species in an ecosystem (Ritchie and Johnson, 2009).

The small indian mongoose (*Herpestes auropunctatus*): biology, ecology, impact and control in insular ecosystems

The small indian mongoose (either referred as *Urva auropunctata* or *Herpestes auropunctatus*) is a mammalian predator whose successful introduction on oceanic islands by humans has led to dramatic adverse impact on native fauna for over a century (Roy, 2001), this species now being introduced on at least 64 islands (Barun et al., 2011), the majority of them being located in biodiversity hotspot areas (Roy et al., 2002). It is listed among the 100 worst invasive species (Lowe et al., 2000). *The small indian mongoose will be referred as "mongoose" in the rest of this report*. Mongooses have been intentionally introduced on islands by humans, mostly to control rat populations in sugar cane fields and due to their ability to prey upon snakes. The small indian mongoose is an omnivorous species, insects constituting the largest part of their diet, but they can also occasionally consume small vertebrates (Hays and Conant, 2007). The deleterious impact of their predation is essentially directed towards native bird species on the islands where they have been introduced, notably participating to the extinction of ground-nesting bird species (Nellis and Everard, 1983), mongooses essentially foraging on the ground (Barun et al., 2011). It has been shown than endemic bird species presence is negatively influenced by mongoose densities (Yagihashi et al., 2021). They may not be directly responsible for bird extinctions on islands, but they often add predation pressure on already threatened native species (Hays and Conant, 2007), while other introduced mammals, especially rodents such as the black rat (*Rattus*

rattus), have already caused and are still causing a lot of damage in these degraded and often fragile ecosystems (Harper and Bunbury, 2015). Despite that, there are still some gaps in our knowledge of mongoose ecology and behavior, both in its native range and in areas where it has been introduced, and thus management protocols for this species are often not fully conclusive (Roy, 2001). Hence, mongoose eradication trials have rarely been attempted in the past, often with low success rates; most of them being implemented in Japan islands of Okinawa, Amami-Oshima and Kyushu (Koike F. and Daigaku Y.K, 2006). However, many mongoose control programs have been locally implemented on islands to reduce the size of their populations. Most islands with introduced mongooses are inhabited, and many of them are too large to consider eradication programs with current developed techniques. Yet, intensive localized control can be seen as a proper alternative to mitigate mongoose impact on threatened native species, as long as such eradication methods are not available (Coblentz and Coblentz, 1985; Barun et al., 2011).

Box traps have been one of the first type of traps used to control and eradicate introduced mongooses on islands. The main advantage of such a live trap is it allows the release of eventual bycatches. However, it appears to not be a fully satisfactory method as it requires a lot of manpower: live traps having to be checked daily for ethical reasons, they also involve manual disposal of trapped animals, and some individuals can't be targeted using such techniques (e.g trap-shy individuals). Killing traps are an efficient alternative to live-traps and have many advantages compared to this method. They require significantly less manpower since they don't need to be checked daily, and there is no need to free the non-target organisms with such a method, while being designed to kill mongooses quickly and humanely. The main disadvantage of using such methods is that they must be specific to the target species and carefully placed to avoid killing non-target native species. Poisoning can also be used as a tool to control mongooses, sometimes in combination with trapping, diphacinone (an anticoagulant) being the toxin currently having the best specificity towards mongoose (Barun et al., 2011). Using poisonous baits via delivery bait stations can be combined with other control techniques such as a killing traps grid, with an "anti-mongoose" fence to maximize control level like for mongoose eradication program in Okinawa Island, Japan (Goodnature website, "featured stories"). The use of toxic baits can be an effective way to reduce mongoose population in a given area, however, it's often very difficult to have target-specific toxic baits and baiting stations, which is a major issue regarding unintentional poisoning of native threatened species. In a nutshell, new techniques and improvements in current control and eradication methods are needed to target larger areas in tropical islands (Roy et al., 2002); while increasing the application rate of already existing control methods (i.e trapping, poisoning…) to other areas. In order to achieve such goals, biological studies are needed to increase knowledge about mongoose biology and behavior (Harper and Bunbury, 2015; Ringler et al., 2014; Roy et al., 2002) alongside improvements in current control techniques. It notably includes better understanding the activity and distribution patterns of this species (Louppe et al., 2021), and finding preferential baits to efficiently attract mongooses to traps (Pitt et al., 2015).

Mauritius: conservation issues, threats to endemic fauna, control of the small indian mongoose

Mauritius is a volcanic oceanic island of the western Indian ocean, located in the Mascarene archipelago, which falls into one of the 25 biodiversity hotspots. This island harbors a remarkable concentration of endemic species, due to its location, age, isolation, and varied topography (Griffiths C. and Zuël N., 2021). Many of these species are threatened by habitat loss and invasive alien species, making Mauritius a high priority location for conservation action (Mittermeier et al., 2011). In fact, because of anthropogenic activities, more than half of Mauritius native vertebrate species have gone extinct and there is now only 2% of native forest remaining in Mauritius (Cheke, 1987*)*, thus concentrating the populations of threatened terrestrial species on remote and relatively small areas.

Mongooses were introduced in Mauritius at the beginning of the 20th century to control rat populations in sugar cane fields. They are now widespread all over the main island, even in some mountainous and relatively inaccessible areas. *Roy et al.* have found that mongooses in Mauritius are not territorial with home ranges varying from 0.25 to 1.10 km2, their density can reach 50 individuals/km2 in certain habitats, they have a broad dietary niche that only slightly fluctuates seasonally and locally, with degraded forest, riparian and rocky habitats as most favorable habitats (Roy 2001; Roy et al., 2002). Mongooses have notably been thought to have been responsible for the local extinctions of native species such as Audubon's shearwater (*Puffinus l'herminieri*) (Cheke, 1987) and of some ground-based skinks (Vinson and Vinson 1969*;* Jones 1988). The management of this invasive species therefore consists of an important part of predator control carried out as one of the main conservation efforts in the island. Even though birds don't constitute a large part of their diet, few predation events can have a dramatic deleterious impact on highly threatened bird species, especially on the endemic pink pigeon (*Nesoenas mayeri*). In this context, the Mauritian Wildlife Foundation, an environment NGO, has started in 1988 a predator control program targeting feral cats, rats and mongooses in particularly sensitive areas of the Black River Gorges National Park, helping a project for the re-introduction of the pink pigeon. Mongoose control has also proven to have played an important role in improving the conservation of the Mauritius kestrel (*Falco punctatus*) (Roy et al., 2002).

Ebony Forest reserve: conservation targets, forest restoration, chronology of predator control, mongoose control strategy and objectives of this study

Ebony Forest reserve is a nature reserve located in the southwest of Mauritius, in the district of Black River (-20.43557°S, 57.37111°E) (Complementary fig. 1). The mission of the conservation team is "to implement conservation, forest restoration, training and education to conserve Mauritius's unique biodiversity." Their main work objectives are to restore 50ha of native forest and to re-introduce locally extinct species. The restored parts of the reserve are subdivided into 134 restoration sites (Complementary fig. 9). The restoration work started in 2006, with more than 28ha of forest that have now been weeded to remove exotic plants, and nearly 153 000 indigenous plants that have already been replanted since 2007 (Griffiths C. and Zuël N., 2021).

Seven out of the nine endemic terrestrial bird species of Mauritius are present in this forest reserve: the Mauritius paradise flycatcher (*Tersiphone desolata*), the Echo parakeet (*Psittacula eques*), the Mauritius black bulbul (Hypsipetes olivaceus), the Mauritius kestrel (*Falco punctatus*), the Mauritius grey white-eye (*Zosterops mauritianus*), the Mauritius olive white-eye (*Zosterops chloronothos)* and the Pink pigeon (*Nesoenas mayeri*). The latter is an endangered land bird that spends long periods of time on the ground, which makes him particularly vulnerable to introduced ground-based predators, thus making predator control a highly important part of the conservation efforts needed to protect this species, as well as for other Mauritius endangered bird species (Roy et al., 2002). Many introduced mammal species are present in Ebony Forest reserve, among which feral cats (*Felis catus*), black rats (*Rattus rattus*), brown rats (*Rattus norvegicus*), the small Indian mongoose (*Herpestes auropunctatus*), the tailless tenrec (*Tenrec ecaudatus*), and the crab-eating macaque (*Macaca fascicularis*) have the most deleterious impact on native vertebrate fauna. Rats prey on amphibians, reptiles, birds' eggs and chicks; cats prey on small mammals, reptiles, amphibians, birds. Crab-eating macaques eat adult, chick and birds' eggs, tenrecs eat native invertebrates while mongooses prey on small mammals, amphibians, reptiles, birds.

It led to the set-up of a predator control strategy in the reserve, whose design is based on the "Mainland Island" concept: "defined areas are isolated by fencing, geographical features or, more commonly, intensive management of pests on the mainland", originally with the aim to protect and restore habitats on mainland of New Zealand through intensive management of introduced pests". It consists here of a control strategy based on a trapping grid using different types of traps, covering the whole reserve, and aiming at controlling all introduced pests (Ebony Forest course, "Introduction to predator control as a conservation tool"). Non-target specific box traps and Goodnature A24 self-resetting killing traps have been used starting from 2017 to try to control several of these mammalian pests in the reserve. Box traps have however stopped to be used in 2020, as their trapping success seemed to be largely dependent on trappers' skills. Goodnature A24 traps have been first tested with 30 traps placed in a 2ha trapping grid, which has then been expanded to cover 19ha of the reserve in 2020. The trapping grid extension then progressively continued, with the aim of covering the whole 50ha of the reserve that has recently been reached this year. DOC 250 killing traps have also been used, but were then progressively replaced by Timms kill traps, since they didn't have the ability to target both feral cats and mongooses. Still, Timms traps are not the most favorable way to control mongooses since they can induce some issues with ethically killing juveniles and are thus used in combination with Goodnature A18 killing traps. Monkey live-traps baited with sugar cane have also been placed at the periphery of the reserve, to limit crab-eating macaques' incursion into the core of the reserve. Goodnature A24 traps are essentially used to target rats and other rodents, with cocoa-flavored pasty lures. Timms traps can help controlling feral cats, tenrecs, mongooses, and rats, and are used with salted dry fish as bait, that have been proved to be good attractants for mongooses in Mauritius (Roy, 2001). Both Goodnature A24 and A18 traps work the same way: first, lure attracts the pest into the trap, then pest moves the trigger firing the trap, killing it instantly, and finally the pest drops as the trap automatically reset itself and the lure continues to attract pests. Goodnature A18 traps differ from A24 traps by their wider entrance, their more powerful trigger, and by the number of times they can automatically reset, respectively 24 times for Goodnature A24 traps and 18 times for Goodnature A18 traps. The latter were firstly designed to target mongooses but were mostly used to trap grey squirrels since they are particularly efficient to target them, while still having the ability to trap rats and other large rodents. The current trapping grid of Ebony Forest is composed of 529 Goodnature A24 traps, 187 Goodnature A18 traps and 56 Timms traps systematically placed in the 50ha of the reserve, one A24 trap being placed every 25m: Gooodnature company advising a density of one trap every 50m for automatic-resetting traps for an effective control of rat populations in tropical forests (N. Zuël 2023, pers. communication); one A18 trap every 50m and one Timms trap every 100m (Complementary fig. 10). The efficiency of EFR trapping grid had been monitored by the conservation team of the reserve via "predator-index" procedure, comparing occurrences of all predator species between the trapping area and a control area in the reserve once every two weeks. 20 camera-traps were used in the trapping area and the same amount in the control area (*see "Appendix" section for detailed methodology*). The uptake of baits used with mongoose traps still needing to be investigated (Roy et al., 2002), several different baits have been tested with Goodnature A18 traps, but only for short periods of time, successively dry-salted fish baits (that didn't appear to be efficient at attracting mongooses with this kind of trap), and petroleum-jelly mixed with different smelly attractant: dry-salted fish, fish sauce, sardine and cat pellets, coming up with a mix of petroleum jelly, fish sauce and cat pellets as a potential good attractant.

In this context, the main initial objectives of this study were defined as follow:

- **The first objective was to develop, test and compare different candidate baits to be used with Goodnature A18 traps, to find the best lure composition to attract mongooses into these traps, doing camera-trap monitoring of deactivated traps containing different types of lures.**
- **The second objective was to set up a "mongoose index" to compare mongoose occurrences between the trapping area of Ebony Forest and a control area, using both differences in the number of mongooses spotted on camera traps between these two areas.**
- **The last objective was to compare the efficiencies of Goodnature A18 traps and Timms traps, including both mongooses attractance to bait and trapping success, in sites where both types of traps are present.**

As very scarce data was collected on mongooses attractance to Goodnature A18 traps and their associated candidate baits, as well as on actual mongoose trapping events in both A18 and Timms traps, the main objective of this study was broadened. It was then defined as "improving the efficiency of mongoose control strategy in Ebony Forest reserve"; while increasing in a wider perspective knowledge about mongoose ecology and behavior, to improve its management in insular ecosystems outside of its native range.

2. Material and Methods

2.1 Objective 1: Goodnature A18 bait tests

The first objective of this study was to develop, test and compare different candidate baits to be used with Goodnature self-resetting A18 traps, to find the best bait composition in order to control the small Indian mongoose (*Herpestes auropunctatus*) in Ebony Forest reserve (abbreviated "EFR" in the rest of this report) as efficiently as possible. The candidate baits tested had to be attractive and should ideally have a "pasty" texture to fit in A18 bait's cups (petroleum-jelly can for instance be used to give baits such texture), while also being attractive for rats since A18 trapping grid of EFR has been set to control both mongooses and rats (Dr. Nicolas Zuël 2023, pers. communication). Baits also must be long lasting and not too attractive to invertebrates: traps being routinely checked once every 2 to 3 months; and relatively cheap and easy to prepare and use; these parameters being essential in the determination of the final bait selection (Pitt et al., 2015). The composition of the 6 candidate baits and the control bait that were tested were as follow, using ingredients that have the potential to attract mongoose by their smell, and that can be easily found in Mauritius and that are relatively cheap:

Table 1: Composition/id of the different candidate baits for Goodnature A18 bait tests

Bait_number	**Bait_id**	**Bait composition**
Bait 1	KB	crushed cat pellets, fish sauce, petroleum-jelly
Bait 2	CO	coconut-oil, petroleum-jelly
Bait 3	CCC	coconut-oil, wax
Bait 4	FS	fish sauce, petroleum-jelly
Bait 5	S	sardine can (fish + oil), petroleum-jelly
Bait 6	CP	crushed cat pellets, petroleum-jelly
Bait 7	*V*	*petroleum jelly*

The composition of "Bait 1" was developed by a member of the EFR conservation team a few weeks before the beginning of this study and seemed to have the potential to attract mongooses in EFR. "Bait 3" has a completely different texture than all other tested baits as it corresponds to small pieces of wax cubes that were intended to be tested as chew cubes for EFR predator-index, if they appeared to be attractive for mongooses in this test. "Bait 7" corresponds to the control bait, having no distinctive odor. Most of the tested baits contained either fish or fish and coconut by-products, as both can be very attractive baits for mongooses, eliciting multiple visitations (Pitt et al., 2015). Mongoose anal gland secretion was also considered to be tested as a bait considering its general role in social interactions among carnivores that could be used to attract mongooses to traps (Howard et al., 2002; Pitt et al., 2015). It was then put aside, mainly for ethical reasons as it would have involved dissections of mongooses using live traps; besides this bait probably wouldn't have been a good attractant for rats.

The candidate baits for Goodnature A18 traps were tested as follow:

- **Phase 1**: "small-scale" test of all candidate baits, with 8 sampling units per bait, 24h of test per week, for 3 weeks long. All baits were put in supplementary A18 traps (i.e different from A18 traps already set in the trapping grid of the reserve) and deactivated to estimate mongooses' preferences in terms of attractance between all candidate baits present at each site. Each of the 7 candidate baits was present at each site, all put in different traps. They were grouped together for each sampling unit, lined, and elevated from the soil (around 20cm, to fit with mongoose physiognomy) with a random attribution of the order of each candidate bait along the lines (Complementary fig 2.). A letter code was assigned to each trap to designate the type of bait put inside (Table 1). Each sampling unit was randomly positioned in the Goodnature A18 trapping grid of EFR, at equal distance between 2 consecutive "already-set" A18 traps of the grid (i.e distant from 25m to these traps) (Complementary fig 3). More precisely, the number of sampling units in each area was proportional to their total area (i.e random-stratified sampling): 2 sampling units in open canopy areas (total area = 12.16ha) and 6 sampling units in closed canopy areas (total area = 32.52ha, including 12.50ha of unrestored forest).
- **Phase 2**: "large-scale" test of the 2 most attractive baits selected from *Phase 1*, for 8 to 10 weeks. A18 traps already set in the EFR trapping grid were used to test baits efficiency for this second phase; with 6 sampling units for each of the 2 selected baits, and 48h of monitoring every week.

  -> *BAIT 1: M33, M118 (open canopy), M155, M116, M40, M23 (closed canopy)*

  -> *BAIT 2: M68, M88 (open canopy), M99, M12, M102, M180 (closed canopy)*

For both phases: each bait was randomly assigned in the whole 50 ha trapping grid to an A18 trap, with a minimal distance of 100m between each site. The attractivity of all baits was estimated via camera-trap monitoring of the A18 traps to which the baits were assigned; one camera-trap being placed at immediate proximity of each sampling unit (i.e between 0.5 to 3m). Camera-traps used for this test were Crenova 20MP PH760 Hunting Trail Camera, which was also the case for monitoring in “work objective 3” (*with also the use of one UVision UV557 Mini 8MP No-Glow Scouting camera when one of Crenova camera-traps wasn’t available*). A bait is considered to be a good attractant when the target species sniffs the bait cup for more than 2 to 3 seconds and/or target individuals put their head in the trap entrance. Camera-traps were placed not too close to roads or pathways to limit the risk of theft. 1 min-long videos were recorded each time camera traps were triggered by motion, and data was collected once in a week. Occurrences of all mammal species taken by camera traps were recorded. The underlying hypotheses for this objective were as following:

- Mongooses will be more attracted to the smelliest baits than to baits having a less distinct odor (since baits are not visible to mongooses when enclosed inside A18 traps bait-cups)
- The most attractant bait for mongooses will also be a good attractant for rats (as they are known to be less “selective” than mongooses)
- Mongooses may be differentially attracted to baits placed in open-canopy areas compared to closed-canopy areas regardless of the type of candidate bait that is used, since significant differences in canopy cover between these 2 types of habitats could induce differences in resources availability and number of available dens sites (Roy, 2001)

All statistical analyses were performed on RStudio software (2023.03.1+446 version) and spatial analyses were done using qGIS software (3.22 version, Bialowiesa).
One way ANOVA will be used to compare the number of mongoose attractance events between the different candidate baits; as well as potential differences of attractance for rats between the different candidate baits. Generalized Linear models will be implemented to account for the significance of the influence of variables: “bait type”, “bait freshness”, “canopy-cover”, “majority of plant species", “latitude”, “longitude” and “date” on mongoose attractance events.

2.2 Objective 2: Mongoose index

The second objective was to set up a “mongoose index” to compare mongoose presence between the treatment/trapping area of EFR and a control area. To do so, we used data about the number of mongooses spotted on camera traps during the baited predator-index performed in the reserve from July 2020 to December 2022 (whose methodology was presented in the introduction of this report) as well as Timms traps data already collected about mongoose trapping in the reserve from November 2020 to January 2023. A supplementary indirect census method was also thought to be tested alongside camera-traps: mongoose’s chew-cubes. As stated earlier in the report, they have the same composition as “Bait 3” and would only be tested if they appeared to be efficient bait for mongooses in Phase 1 of bait tests. **The main goal of doing such analyses was to identify hotspots with high mongoose densities in the reserve.** The ultimate aim is then to keep doing such analyses with data of current and future predator-index (i.e starting from April 2023) and both Timms traps and Goodnature A18 trapping data, to look for the spatial consistency or evolution of such critical sites where the trapping strategy should be adapted in the near future (i.e increasing mongoose trapping effort). The methodology of statistical and spatial analyses for this work objective was as follow:

a- Mongoose occurrences on camera-traps during previous predator-index, between July 2020 and December 2022:

- Comparing the number of mongoose occurrences on camera-traps during predator index in each site, between trapping and control areas via a Wilcoxon rank sum test.
- Influence of coordinates, canopy-cover, majority of endemic/exotic plant species on the number of mongooses occurrences on camera-traps -> Generalized Linear Model (GLM) with Poisson distribution and log link function, transforming both the majority of endemic vs exotic plants and canopy cover into factor variables and assigning numerical values to the factor levels. The following combinations of explanatory variables were considered for the different GLMs: *model0 <- glm(mongoosesCT_tot ~ 1, data = mongCTindex_sites); model1 <- glm(mongoosesCT_tot ~ long + lat + canopy_cover + endemic_exotic, data = mongCTindex_sites); model2 <- glm(mongoosesCT_tot ~ long + lat + canopy_cover, data = mongCTindex_sites); model3 <- glm(mongoosesCT_tot ~ long + lat + endemic_exotic, data = mongCTindex_sites); model4 <- glm(mongoosesCT_tot ~ canopy_cover + endemic_exotic, data = mongCTindex_sites).* The comparisons of the different GLM were then made using the Akaike Information criterion (AIC).
- Differences between mongoose occurrences on camera-traps during predator-index between sites 1) located in open vs closed canopy areas and 2) majority of endemic vs exotic plant species, via t-tests.
- Check which parameters explain the greatest proportion of the variation in the number of mongoose occurrences on camera-traps during predator index -> Regression tree (which is useful when the relationships between the independent variables and the dependent variable are not linear); using R packages “rpart”, “partykit” and “party”.
- Identify the spatial localisation of sites/clusters of sites where more mongoose occurrences were recorded; while also estimating the impact of forest restoration on the presence of

mongoose occurrences during previous predator index -> Heatmap of mongoose occurrences (qGIS software).

b- Mongoose trapping in Timms traps (previous Timms traps grid, data collected from November 2020 to February 2023)

- Influence of the coordinates, distance to fence, canopy cover and majority of endemic vs exotic plant species on the number of mongooses trapped in Timms traps -> Generalized Linear Model (GLM) with Poisson distribution and log link function. The following combinations of explanatory variables were considered for the different GLMs: *model0 <- glm(trapped_mongooses ~ 1, data = mongtrappedTimms); model1 <- glm(trapped_mongooses ~ long + lat + CLdist_fence + canopy_cover + endemic_exotic, data = mongtrappedTimms); model2 <- glm(trapped_mongooses ~ long + lat + canopy_cover, data = mongtrappedTimms); model3 <- glm(trapped_mongooses ~ long + lat + endemic_exotic, data = mongtrappedTimms); model4 <- glm(trapped_mongooses ~ canopy_cover + endemic_exotic, data = mongtrappedTimms); model5 <- glm(trapped_mongooses ~ CLdist_fence + canopy_cover + endemic_exotic, data = mongtrappedTimms); model6 <- glm(trapped_mongooses ~ CLdist_fence + endemic_exotic, data = mongtrappedTimms); model7 <- glm(trapped_mongooses ~ CLdist_fence + canopy_cover, data = mongtrappedTimms); model8 <- glm(trapped_mongooses ~ CLdist_fence, data = mongtrappedTimms).* The comparisons of the different GLM were then made using the AIC.
- Identify the spatial localisation of sites/cluster of sites where more mongoose trapping were recorded, while estimating the impact of forest restoration on mongoose trapping; and also check if the location of such sites also matches the location of sites where more mongoose occurrences were recorded during previous predator-index -> Heatmap of mongoose trapping in previous Timms traps grid (qGIS software).

The underlying hypotheses for this objective were as follow:

- The number of mongooses occurrences should be significantly higher in the control area in comparison with the trapping area (while considering differences of size between these two areas)
- Mongooses' occurrences may be higher in areas dominated by exotic plant species (i.e poorly or non-restored parts of the reserve) compared to areas dominated by native plant species (i.e well-restored parts of the reserve), as mongoose densities in Mauritius have shown to be higher in exotic-plant dominated habitats than in forest habitats dominated by native plants (Roy, 2001). It could enable us to measure the eventual influence of forest

restoration on mongoose presence in the reserve (sites invaded by exotic plants often being more densely vegetated than native plants dominated sites*)*.

2.3 Objective 3: Goodnature A18 and Timms traps sites monitoring

The third objective of this study was to compare the efficiency of Goodnature A18 traps with Timms traps. We compared mongoose attractance to either A18 or Timms traps baits, and differences of trapping success rates between the two types of traps, in sites where both Timms and A18 traps were present at the same location (Fig.1), via weekly 24h camera-trap monitoring sessions (Complementary fig. 4.) The most attractant candidate bait elicited in phase one of bait tests was first thought to be used for A18 traps in this test, but the lack of results in bait tests led to the decision to keep using the same bait used in all the trapping grid (i.e KB bait); salted-dry fish being used as bait in Timms traps.

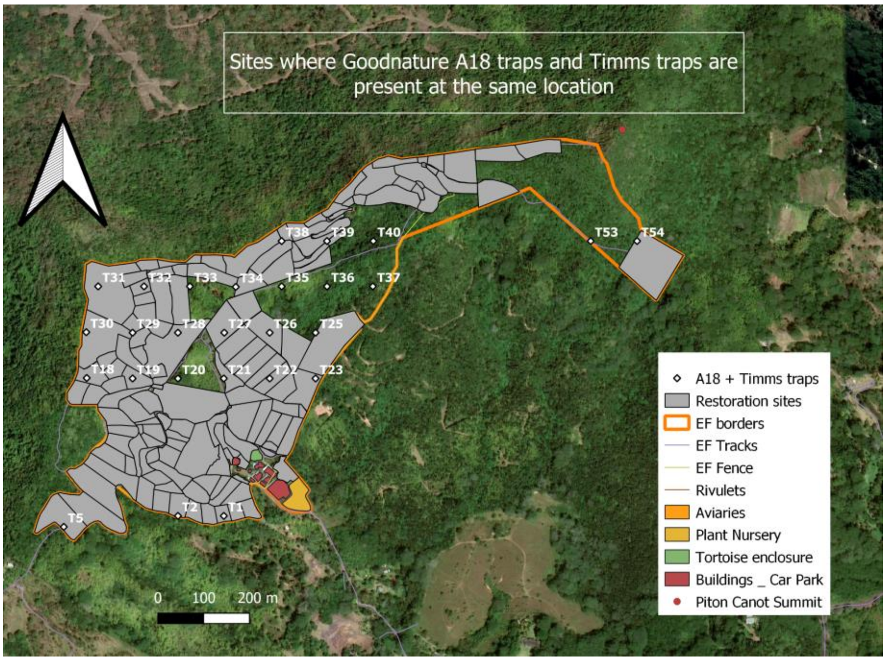


Fig. 1: Spatial localisation of the sites where both Goodnature A18 and Timms traps are present in the same location within Ebony Forest trapping grid

Out of the 27 sites of the trapping grid where both Goodnature A18 and Timms traps are present, 4 were selected in open canopy areas and 12 were selected in closed canopy areas (i.e considering the relative surface of each habitat), with a minimal distance of 100m between each site (i.e minimal distance between 2 Timms traps).

Rainfall was measured at the same hour every day, in a site close to EFR field station, to account for its eventual influence on trapping success. Other weather parameters such as daily minimum, maximum or average temperatures were not included in this test as it would have required recording them daily at several different locations within EFR, and since they can vary greatly even at a fine spatial scale considering differences of vegetation cover.

The underlying hypotheses for this objective were as follow:

- Goodnature A18 traps should show a better efficiency at both attracting and trapping mongooses in comparison with Timms traps, the latter not being designed to specifically target mongooses
- Overall trapping success (i.e for both A18 and Timms traps) should be significantly lower during rainy days than during days with no rainfall, rain significantly decreasing mongooses foraging activity (Barun et al., 2011)
- Both Goodnature A18 and Timms traps could show different levels of attractance and trapping success in open-canopy areas than in closed-canopy areas
- Both Goodnature A18 and Timms traps should show higher attractance and trapping success in areas dominated by exotic plant species (i.e poorly or non-restored parts of the reserve) compared to areas dominated by native plant species (i.e well-restored parts of the reserve)

The absence of mongoose occurrences during both first and second sessions of the phase one of bait tests has led to a redefinition of the methodology for this objective, since chances were that very few mongoose occurrences on camera-traps and trapping could be recorded in sites randomly designated within the trapping grid area of EFR for this trap monitoring test. Instead, the new protocol focused on sites located at the periphery of EFR trapping grid and sites located close to the core of the grid. The third objective was still to compare the efficiency of Goodnature A18 traps and the attractiveness of their baits with those of Timms traps; however, we made a distinction here between sites located close to the border of the reserve (i.e located at the periphery of the trapping grid, less than 50m from the border), and sites located at the core of the trapping grid (i.e >100m of EFR border). We thus also tested if the position of traps within the trapping grid had no influence on mongoose occurrences and trapping, comparing these border vs core sites; *Roy* having found that the position of traps within trapping grid, using live traps, seemed to not have an influence on mongoose trapping success in Mauritius (Roy, 2001). Mongoose occurrences and trapping still could be lower in sites located close to the core of the trapping grid where the impact of trapping effort is potentially higher compared to sites located at the periphery of the grid, since no mongoose control is occurring at immediate proximity outside of EFR. The methodology for this test was therefore adapted: the duration of the weekly camera-trap monitoring was reduced to 24h to limit the risk of theft, with a total of sixteen monitored sites (equally divided between core and periphery areas) and fourteen monitoring sessions per site. Yet, it wasn't possible to assess the potential influence of canopy cover on mongoose occurrences and trapping with these modifications of the methodology, as almost all sites located close to the border of the reserve had a closed canopy. A pilot test was first conducted to validate the feasibility and likelihood of having sufficient data for this test, with five sites for both border and core areas. Two mongooses were spotted on camera-traps during this pilot test, which led us to start the "large-scale" traps monitoring with eight sites for both border and core areas, as it was planned. The methodology of the statistical and spatial analyses that were planned were as follows:

- Statistical analyses :

The differences in bait attractance and trapping 1) between Goodnature A18 and Timms traps, and 2) between core and border sites (i.e regardless of the type of trap) will be analyzed via T-tests (or nonparametric Wilcoxon rank-sum test). *Exploratory analyses will be computed via Principal Component Analysis (PCA) to account for the influence of quantitative variables: "bait freshness", "date", "longitude", "latitude", "closest distance to EFR border", "rainfall" and "time of detection", on the global variance in mongoose attractance and trapping (for both types of traps).*

- Spatial analysis:

The spatial localisation of (eventual) clusters of monitored sites where more mongoose attractance and trapping were recorded in both types of traps will be identified via heatmaps (qGIS). Timelapse videos will be performed using "Time-manager" extension (qGIS), to look for eventual spatio-temporal patterns in mongoose activity and trapping.

3. Results

3.1 Goodnature A18 bait tests

The duration of camera-trap monitoring sessions was increased between the first and the second session of bait tests (phase one) since no mongoose presence was recorded. Then, the absence of mongoose also during the second session has led to the decision to re-do the bait tests from the beginning in a different site, where mongoose densities are supposedly higher because no predator control is occurring there. A pilot test was conducted for one week in a 2ha area located close to Ebony Forest (i.e 1km from the reserve). Four monitoring points were positioned in this area, with a minimum distance of 50m between each point. One mongoose was spotted in one of the 4 points during this 3 day-long pilot test. It led us to consider re-doing the 3 weeks-long phase one of bait tests from the beginning in this area, while fixing problems encountered during the pilot test and expanding the study area with an adjacent area of 4ha to position eight sites with a minimum distance of 50m between each site. Three mongoose occurrences were recorded on the camera-trap of "site4", but none of the individuals seemed attracted by the bait: they just passed in front of the camera-trap. A mongoose was also spotted on a camera-trap in "site8", and this individual seemed attracted by the bait containing cat pellets and fish sauce (i.e "KB"). Several issues were encountered during the first session of these tests; the main one being that camera-traps of "site1" and "site2" were stolen. It led us to take the decision to stop doing the phase one of bait tests in this location to prevent the theft of other camera-traps. We thus decided to re-do the phase one of bait tests inside Ebony Forest reserve, like for the first and second sessions of these tests, but only focusing here on sites located close to the border of the reserve, as the influence of predator control should be lower at the periphery of the trapping grid, and limiting the duration of camera trap monitoring of each weekly session to 24h to reduce the risk of camera-trap theft. The eight following sites were considered for this 2 weeks-long test (Fig.1):

=> *M111_110 ; M81_72 ; M14_27 ; M117_116 ; 25m_M135 ; M140_139 ; M105_115 ; M106_97*

The absence of mongooses during these 2 sessions of bait tests has led to the decision to stop doing this test.

A different approach was then tested as an alternative to test the candidate baits, which consisted in binocular monitoring in sugar-cane fields of Goodnature A18 traps with the different baits to test. A first pilot test was conducted for 3h, with 5 boards with 7 candidate baits on each board, monitored by 3 persons posted at a certain height above the traps. The candidate baits remained the same as for previous bait tests, except two of them that appeared to have a poor environmental resistance: the sardine bait (code "S") and the coconut chew-cube bait (code "CCC"). These two baits were instead replaced by dry-salted fish and Bombay-duck fish: the first appeared to be a good attractant for mongooses in live-traps in the past (Roy, 2001) and the second was tested as a new candidate bait for mongoose traps considering its very strong smell and its potential good environmental resistance. No mongoose was spotted during this pilot test which led to the decision to not continue this test.

It then led to the decision to stop doing any other bait tests experiment but rather focusing on the monitoring of the sites with both Goodnature A18 and Timms traps, considering the overall absence of results for this work objective.

3.2 Mongoose index

3.2.1 Mongoose occurrences on camera-traps during previous predator-index

Results of the Wilcoxon rank-sum test: the median scores of "mainland" and "control" are significantly different (i.e p-value < 5%), meaning that there were less mongoose occurrences on camera-traps in the mainland area compared to the control area during previous predator-index.

Results of the Generalized Linear Models and regression trees:

The best model appears to be “model 4” (Complementary fig. 6): the model using canopy cover and majority of either endemic or exotic plant species as explanatory variables for mongoose occurrences on camera-traps.

Results of the regression tree show that “latitude” is the variable that explains the greatest proportion of the variation in the number of mongoose occurrences on camera-traps, then the "canopy-cover" variable intervenes in a second phase to distinguish 2 sub-groups (Complementary fig. 7).

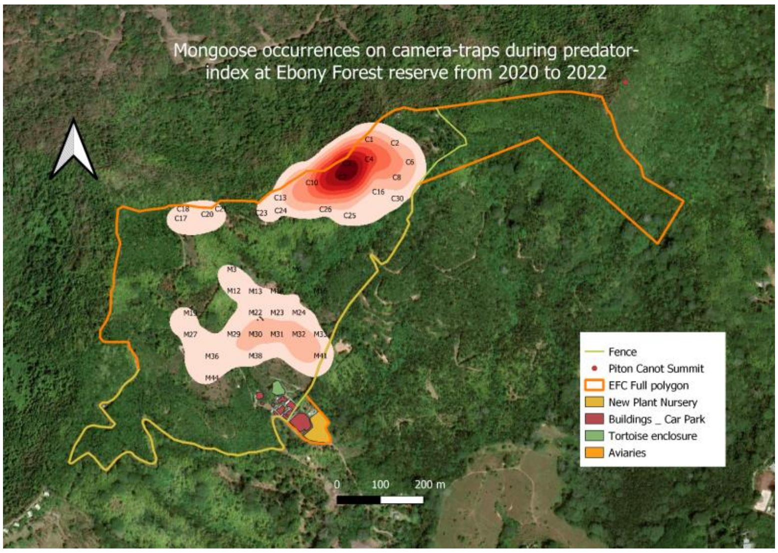


Fig. 2: Heatmap of the mongoose occurrences on camera-traps during the previous predator-index carried out in the reserve from 2020 to 2022

Results of qGIS heatmap: there is a clear area within the control area with higher number of mongoose occurrences around sites C3, C4 and C7 (Fig.2). There is no identifiable zone with a higher number of mongoose occurrences in the trapping area.

Impact of forest restoration measured via the majority of plant species present in each restoration site (i.e either endemic/exotic/mixed) on the number of mongooses spotted on the camera-traps during the previous predator-index (Complementary fig. 12): The total area of sites having a majority of endemic plant species in the previous predator-index area was 9.4ha in the control area and 7.0ha in the trapping area. The total area of sites having a majority of exotic plant species in the previous predator-index area was 3.2ha in the control area and 2.1ha in the trapping area. Only one restoration site had neither a majority of endemic nor exotic plant species (i.e "mixed" plant species) in both control and trapping areas, whose areas were respectively 0.7ha and 0.3ha. There were on average 4.2 mongooses/ha in restored sites (i.e majority of endemic plants) against 6.5 mongooses/ha in non-restored sites (i.e majority of exotic plants); and 16.2 mongooses/ha in the only "mixed" site in the control area. In the trapping area, there were on average 4.9 mongooses/ha in restored sites, but only 2.4 mongooses/ha in non-restored sites; and 5 mongooses/ha in the "mixed" site.

3.2.2 Mongoose trapping in Timms traps in previous Timms traps grid

Results of the Generalized Linear Model (GLM):

Comparisons of the different GLMs with the null model using AIC: no better model than the null model (Complementary fig. 8).

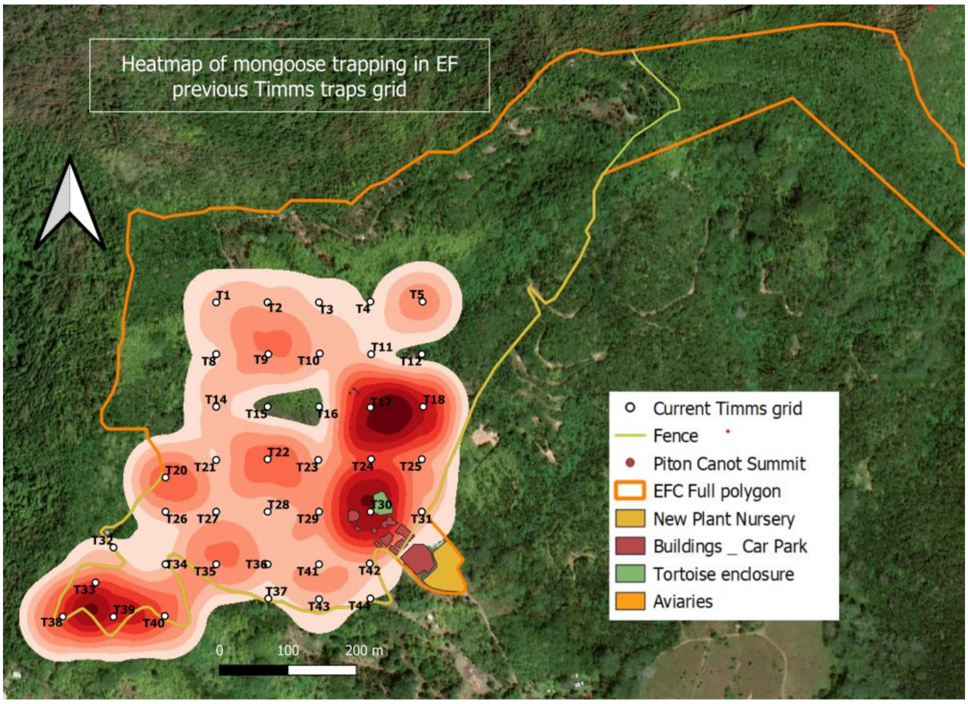


Fig. 3: Heatmap of mongoose trapping in the previous Timms trapping grid of Ebony Forest, from 2020 to 2023

Three distinct areas where more mongooses were trapped in Timms traps can be identified (Fig.3): one corresponding to the sites around the aviaries, one around the tortoises' enclosure, and another one at the south-west extremity of the reserve.

Impact of forest restoration on the number of mongooses trapped in previous Timms grid, whose area corresponds to same area as the trapping area of the previous predator-index: on average 8.7 mongooses were trapped/ha in restored areas (i.e 129 individuals over a total surface of 14.9 ha), 3.6 mongooses trapped/ha in unrestored areas (i.e 8 mongooses over a 2.3ha area); and 9.4 mongooses trapped/ha in "mixed" areas (i.e 3 trapped individuals in one "mixed" site of 0.3ha).

3.3 Goodnature A18 and Timms traps sites monitoring

Two mongooses were spotted on camera traps in sites located at the periphery of the reserve during the pilot test, with one mongoose showing marking behavior on a Timms trap (-> site T2/m112). A second selection of baits was also tested for both Goodnature A18 and Timms traps due to the fact that "KB" bait didn't seem to attract mongooses in A18 traps and that several dry-salted fish baits placed in Timms traps were removed by tenrecs and mongooses without triggering the traps. Thus, Bombay duck fish was tested as a bait for both types of traps, for half of the monitoring sessions (in order to compare the efficiency of this bait to dry-salted fish in Timms traps), this bait having a potentially good environmental resistance. It could indeed be harder to remove from Timms traps without triggering them, having a better resistance to moisture than "KB" bait in Goodnature A18 traps, while still having a very strong smell that can attract mongooses. The aim of this part of the test was thus to test Bombay duck as a candidate bait for both Timms and Goodnature A18 traps, while obtaining information about the potential differences of mongoose attraction to either Timms or A18 traps when using the same bait in different conditions: the bait being visible in Timms traps and enclosed in a cup in Goodnature A18 traps.

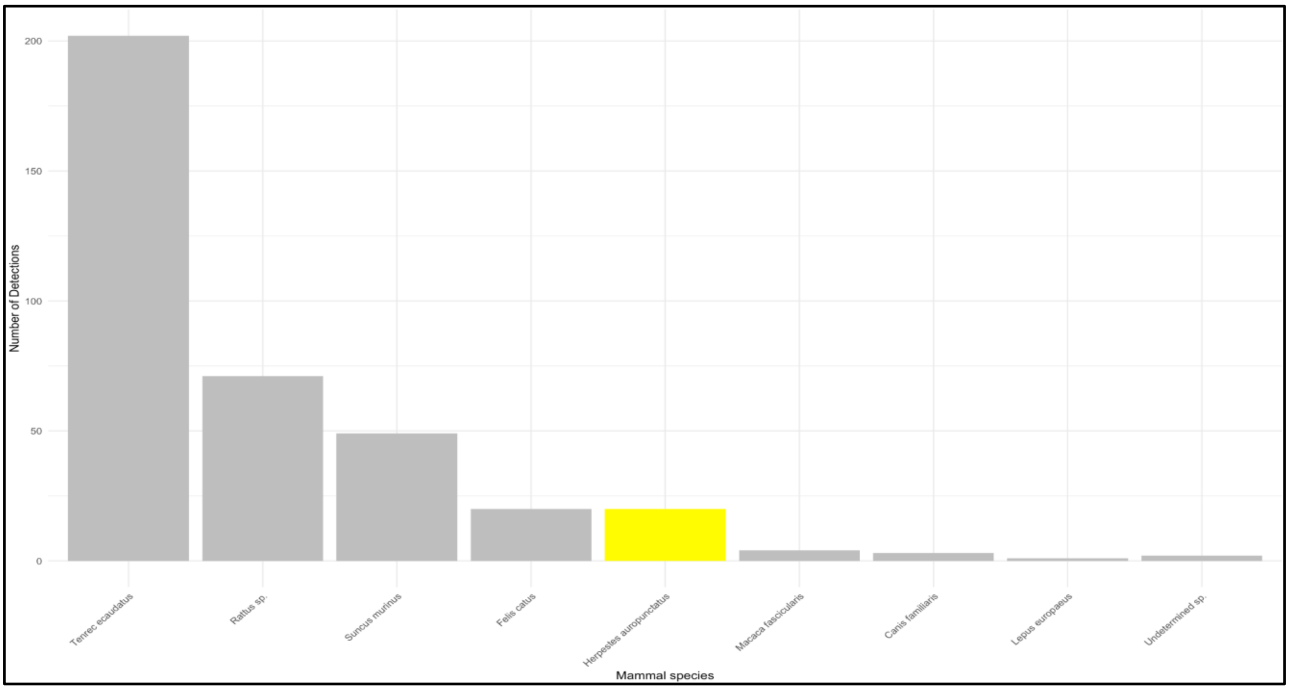


Fig. 4: Total number of mammal detections on camera-traps during the monitoring of Goodnature A18 and Timms traps sites

Out of the 373 detections of mammals on camera-traps during the fourteen sessions of camera-trap monitoring, only 5% were mongooses; *Tenrec ecaudatus* representing the most detected species (54%), followed by *Rattus sp.* (19%), *Suncus murinus* (13%) and *Felis catus* (6%) (Fig.4).

session	setting_date	grid_location	site_id	long	lat	rainfall (mm)	time of detection	Timms_bait_type	A18_bait_type	Timms bait_freshness (days)	A18 bait_freshness (days)	trap_attractance	trapped_individual
session1	04/04/2023	core	T29	57.36908	-20.43404	3.7	12h33	DSF	KB	*NA*	*NA*	Timms	no
session1	04/04/2023	core	T29	57.36908	-20.43404	3.7	09h05	DSF	KB	*NA*	*NA*	Timms	no
session2	13/04/2023	core	T27	57.37411	-20.43307	0	09h49	DSF	KB	1	1	none	no
session2	13/04/2023	border	T2	57.37003	-20.43788	0	07h09	DSF	KB	1	1	Timms	no
session3	19/04/2023	core	T29	57.36908	-20.43404	0	13h41	DSF	KB	7	7	Timms	no
session4	26/04/2023	core	T19	57.36908	-20.435	0	08h48	BD	BD	1	1	Timms	yes
session4	26/04/2023	border	T18	57.36812	-20.43499	0	07h54	BD	BD	1	1	Timms	no
session5	02/05/2023	border	T5	57.36764	-20.43811	0	NA	BD	BD	7	7	Timms	yes
session6	09/05/2023	core	T29	57.36908	-20.43404	2.9	09h08	BD	BD	NA	14	none	no
session6	09/05/2023	border	T18	57.36812	-20.43499	2.9	09h50	BD	BD	NA	14	Timms	yes
session8	15/05/2023	border	T2	57.37003	-20.43788	1.3	08h35	BD	BD	NA	20	Timms	yes
session9	22/05/2023	core	T27	57.37411	-20.43307	0	NA	BD	BD	1	27	Timms	yes
session11	31/05/2023	core	T27	57.37411	-20.43307	13.8	10h06	DSF	KB	1	1	none	no
session11	31/05/2023	core	T29	57.36908	-20.43404	13.8	12h22	DSF	KB	1	1	Timms	no
session12	06/06/2023	border	T2	57.37003	-20.43788	1.8	09h26	DSF	KB	1	7	none	no
session12	06/06/2023	border	T18	57.36812	-20.43499	1.8	10h31	DSF	KB	1	7	none	no
session12	06/06/2023	border	T18	57.36812	-20.43499	1.8	10h32	DSF	KB	1	7	both	no
session12	06/06/2023	border	T23	57.37291	-20.435	1.8	15h49	DSF	KB	7	7	Timms	no
session12	06/06/2023	border	T31	57.36836	-20.43307	1.8	12h59	DSF	KB	7	7	Timms	no
session13	08/06/2023	border	T23	57.37291	-20.435	0	16h27	DSF	KB	9	9	Timms	no
session14	20/06/2023	core	T27	57.37411	-20.43307	0	16h14	DSF	KB	1	21	none	no
session14	20/06/2023	border	T31	57.36836	-20.43307	0	NA	DSF	KB	1	1	Timms	yes
session14	20/06/2023	border	T37	57.37411	-20.43307	0	13h48	DSF	KB	1	21	none	no

Fig. 5: Mongoose occurrences and trapping during and outside of monitoring sessions of Goodnature A18 and Timms traps sites

Out of these twenty mongoose detections on camera-traps, three were actually trapped (15%). Three other mongooses were also trapped in the monitored sites, outside from camera-trap monitoring sessions (Fig.5). 7/23 mongooses weren't attracted to any bait (30.4%) and only one seemed to be attracted to A18 bait ("KB" bait). The average freshness for Timms traps baits that attracted mongooses was four days, with values that didn't exceed seven days for trapped individuals. 13/23 mongooses were spotted in border sites (so 10/23 were detected in core sites). Half of mongoose activity was recorded between 8h35 and 10h35 (10/20 individuals). Besides, 5/20 individuals were detected between 12h15 and 14h, and 3/20 individuals between 15h45 and 16h30. No mongoose was spotted when daily rainfall exceeded 14mm. All mongooses were trapped in Timms traps, most of them using Bombay-duck as a bait (code "BD"): ⅚ trapped individuals (83.3%); two of them were juvenile individuals and weren't killed instantaneously/humanely. Only one mongoose was trapped in Timms traps with dry-salted fish (code "DSF") as bait. No mongoose was trapped in Goodnature A18 traps with any of the two types of baits that were tested.

4. Discussion

4.1 Interpretation of results

4.1.1 Goodnature A18 bait tests

Mongoose population density might be too low in EFR to obtain sufficient data about mongoose attractance to Goodnature A18 tested baits. It's likely due to the impact of predator-control carried out in the reserve; and to a lesser extent, to mongoose habitat preferences in specific areas. In fact, mongooses tend to prefer riparian habitats and areas dominated by exotic plant species over other types of habitats in Mauritius (Roy, 2001). Areas dominated by native-plant species (i.e corresponding to the well-restored sites in EFR) indeed appear to be less favorable habitats for mongooses, which could also be correlated to the fact that they have a very low thermal tolerance and that pristine forests are essentially located in higher altitude areas (Baldwin et al., 1954). As a matter of fact, small-scale tests performed outside of the reserve showed that mongooses could actually be attracted to Goodnature A18 baits when present at higher densities, within an area where no predator-control is occurring, which is also dominated by exotic plant species. Another possible explanation for the scarcity of the obtained results for Goodnature A18 bait tests, is that mongoose attractance towards A18 traps might simply be very low, so poorly measurable. In fact, baits are enclosed in a cup in A18 traps, and thus not directly visible to mongooses so they can only be attracted to the bait's smell; but the fact that the bait is enclosed in a cup could also prevent mongooses from being able to easily detect the bait's smell. The season during which was carried out the study: summer (with a wet and warm climate/weather in Mauritius) is not likely to have had a significant negative impact on mongooses' activity since this species breeding period is relatively constant throughout the year in Mauritius, only avoiding the dry period between May and August (Roy, 2001).

4.1.2 Mongoose index

4.1.2.1 Mongoose occurrences during camera-trap monitoring (previous predator-index)

The results of the Wilcoxon test showed that there were significantly fewer occurrences of mongooses on camera-traps in the trapping area compared with the control area, which is logical/intuitive since no predator-control is occurring in the control area. The impact of mongoose control is thus likely to be the main factor involved. The results of the GLM showed that vegetation cover and the predominance of either exotic or endemic plant species (-> proxy of forest restoration) may have a greater influence on the presence of mongooses than the geographical location of the site itself within the reserve. However, it appeared that there were no significant differences in the number of mongoose occurrences on camera-traps between both closed vs open canopy areas and areas with a majority of exotic vs endemic plant species. The results of the regression tree might seem in contradiction with GLM results concerning the influence of geographical coordinates on the presence of mongooses in the reserve. However, the threshold value for latitude corresponds here to the upper limit of the trapping area (i.e close to the zone separating both areas) (Complementary fig. 7), control and trapping areas not being geographically attached/jointed and showing significant differences in the number of mongoose occurrences (-> results of Wilcoxon test). The two subgroups resulting from the second node of the regression tree show that more mongoose are present in open canopy areas than in closed canopy areas in the control area of the previous predator index, suggesting favorable effect of forest restoration on mongoose presence.

The location of the hotspot of mongoose presence in the control zone (Fig.2) may be due to the topography of the reserve. It is in fact located in a narrow corridor in the north of the reserve, above the border of the ancient trapping grid; it also may constitute a key area for mongoose immigration into the reserve from both sides, since the northern part of the reserve consists of dense invaded forest less easily accessible to mongooses. These sites are also located very close to paths that mongooses can use, with some litter and wastes left by tourists that may attract them. There does not seem to be any direct influence of forest restoration on the presence of mongooses in the reserve, considering the results of average mongoose densities in control and trapping areas of predator index.

4.1.2.2 Mongoose trapping in Timms traps (ancient grid)

The comparison of the different GLMs shows that there isn't any significant influence of coordinates, distance to fence, canopy cover and majority of endemic vs exotic plant species, on the number of mongooses trapped in Timms traps. None of these variables seem to have a direct influence on the location of sites of mongoose trapping in the reserve.

The heatmap of the number of mongooses trapped in the Timms grid revealed 3 distinct areas where more mongooses were trapped in Timms traps: one corresponding to the sites around the aviaries, one around the turtle enclosure, and another at the south-western corner of the reserve:
Both the high density of passerines and other birds around the aviaries, as well as the food in and all around the bird feeders that locally increase rats and shrew population densities attracting themselves their predators (i.e cats and mongooses); may explain the location of this hotspot for mongoose trapping. This site also corresponds to a highly ecologically sensitive area considering the local abundance of threatened endemic bird species coming to this spot of supplementary feeding: *N. mayeri* feeders, *Zosterops chloronothos* and *Psittacula eques* aviaries. It thus makes it a particularly critical site for mongoose predation on ground-foraging bird species like *N. mayeri*. In this regard, a DOC 250 kill trap had been installed near the aviaries to locally increase the

control of rats and mongooses. Several factors could explain the location of the second hotspot: it's a narrow area located in the south-west corner of the reserve with low slope and forest invaded by exotic tree species (and with a hunting area at proximity), which could make it a suitable area for mongoose immigration from outside of the reserve. The last hotspot is located close to several buildings (including a restaurant and offices) with wastes, and close to the plant nursery, with piles of decomposing organic matter that can attract mongoose by their smell, which might explain the location of this hotspot for mongoose trapping. More than two times more mongooses were trapped in areas of restored forest than in unrestored areas (i.e areas harboring a majority of endemic plant species, compared to areas dominated by exotic plants), a finding similar to the one made on the presence of mongooses during the previous predator-index, for the same area. Forest restoration therefore seems to have a "favorable" impact on the presence of mongooses in the reserve, which coincides with the fact that restored areas harbor higher bird densities in EFR (Daniel S., 2022) making them more suitable areas for mongoose foraging. However, it is important to be cautious when drawing conclusions from these results, considering the opposite finding for mongoose presence in the control area of the previous predator-index, and since areas of the restored and unrestored sites are not similar in size for the trapping area (i.e 15ha of restored forest vs 2ha of unrestored sites)**.** Caution must also be taken considering the potential bias linked to the fact that recently restored sites either have fully open or partially open canopy (i.e because of the weeding and removing of all exotic plants during the forest restoration process) (Complementary fig. 11). These recently restored areas thus potentially offer less water and food sources, as well as less available dens sites for mongooses.

4.1.3 Goodnature A18 and Timms traps sites monitoring

Very few statistical tests could be performed given the scarcity of the collected data, thus mainly resulting from qualitative analysis of our data. The interpretations made from such qualitative analysis are therefore mainly hypothetical and must therefore be taken with a certain amount of caution. Both *H. auropunctatus* and *F. catus* are predator species that seem to be present at similar densities in the reserve (representing respectively 5 and 6% of mammals' occurrences on camera-traps); while *Rattus sp.* and *S. murinus* are both meso-predator species and also seem to be present at similar densities in the reserve (respectively 19% and 13%). There doesn't seem to be significant differences in mongoose presence in the full trapping grid of the reserve between core and border areas. Mongooses are entirely diurnal animals (Kavanau, 1975), and seem to be more active during the end of the morning and early afternoon, with an activity pic located around 10 a.m (in summer when most monitoring sessions occurred); and they seem to avoid rainfall when foraging in the reserve, in accordance with *Nellis and Everard* findings (Nellis and Everard, 1983). It is still not possible with the collected data to evaluate if Goodnature A18 traps are actually effective at controlling mongooses in EFR. It seems that they are not efficient at attracting mongooses in the reserve with both the currently used bait and with the different tested baits, but could potentially be efficient at trapping mongooses in EFR when using different baits: since these traps were first designed to target mongooses. On the other hand, Timms traps are more efficient than Goodnature A18 traps at attracting and trapping mongooses when used with the different baits tested in this study. Several explanations might be given: the bait is clearly visible and accessible to mongooses from the outside, the attractance by the smell is also more efficient than for A18 traps. However, Timms traps induce several disadvantages: the environmental resistance of Timms baits is lower than A18 baits, Timms baits quickly being degraded in the environment, Timms traps have to be checked (to remove trapped individuals) and baits have to be changed more often (i.e once a week versus once every 2 to 3 months for Goodnature A18 traps), and there are still some ethical issues with Timms traps not killing humanely juvenile mongooses (as shown by two of our camera-traps records). Bombay-duck fish seem to be the best bait to use with Timms traps in EFR. It is indeed a good attractant for mongooses with a likely remarkable trapping rate, not being easily detached without triggering the trap unlike currently used dry-salted fish.

4.2 Limits/shortcomings of the study

The main challenge encountered during this study was the very limited amount of data that could be collected on the field about mongoose occurrences and bait attractance and trapping, for both Goodnature A18 bait tests and Timms and A18 traps sites monitoring. There hadn't been surveys conducted in the past in EFR to estimate mongoose population density in the reserve, and it wasn't possible to do an accurate estimation with data already collected by the conservation staff, particularly since mongoose control effort has been gradually increasing for the past 3 years (i.e the trapping grid has been extended) to reach a full systematic trapping grid in the reserve for Goodnature A24 and A18 traps and Timms traps since March 2023. More precisely, the fact that almost no data about Goodnature A18 bait attractance for mongooses and that no data could be collected about mongoose trapping events in these traps was the biggest issue encountered, since initial objectives of this study were focused on testing candidate baits for and measuring Goodnature A18 traps efficiency. No data about mongoose trapping success in A18 traps also hadn't been recorded in the past by EFR conservation staff, these traps only being routinely checked once every 2 to 3 months. It led us to expand the range of work objectives, with a new broader goal being "increasing the effectiveness of mongoose control strategy in EFR"; and to focus data analysis on mongoose trapping records in Timms traps, and mongoose occurrences during previous predator-index monitoring (both having being collected by EFR conservation staff in the past).

4.2.1 Goodnature A18 bait tests

Pasty baits automatically delivered with the same system than Goodnature A24 lures are not yet available for Goodnature A18 traps but currently in development by Goodnature company (Kentish Bundhoo 2023, pers. Comm). In the meantime, different bait textures could be tested with Goodnature A18 traps in EFR. Semi-liquid baits that regularly drip down out of the trap could give a better attractance by the bait’s smell if they directly fall outside of the trap, giving visual cues for mongooses. Such candidate bait has actually started to be tested in the reserve (starting from the last week of my internship). It is composed of a mix of bombay duck fish, dry-salted fish, fish sauce with a slight amount of coconut oil. The control bait is the bait currently used in Goodnature A18 trapping grid (i.e “KB”). Five Goodnature A18 traps have been randomly selected within the trapping grid for both tested and “control” baits, with ongoing 24h camera-trap monitoring of these sites every two weeks, while changing the baits when needed (i.e moisture or empty bait cup) and recording the frequency of bait changes. The aim of this test is to check if this candidate bait is more efficient at attracting and trapping mongooses in Goodnature A18 traps than the bait currently used. Different approaches using Goodnature A18 traps could also be tested: different angles/positions for A18 traps (e.g put the trap with horizontal entrance instead of vertical to facilitate the access to the bait for mongooses), replacing bait cup by a transparent one to make the bait visible,...

4.2.2 Mongoose index

It will be useful to record the frequency of canister and bait changes since the completion of the trapping grid extension for Goodnature A18 (and A24) traps, to look for eventual hotspots of traps activity and to check (via camera-trap monitoring) if they correspond to mongoose trapping hotspots. It would also be interesting to check in the future whether the hotspot for mongoose presence in the previous control area of the predator index also corresponds to a hotspot for mongoose trapping in Timms traps new/full trapping grid. It will be interesting to perform spatial interpolation analyses (e.g ordinary kriging) when sufficient data will be available about mongoose occurrences on camera-traps during the “new” predator-index procedure carried out on the whole surface of the reserve (since March 2023), to be able to estimate global mongoose population density in EFR. It could have been interesting to perform a theoretical predictive model for mongoose population density in the reserve, using camera-traps data of ancient index and trapping data of ancient grid of Timms traps. However, the problem is that the new grid is now more extended than the ancient one, the old control area now being integrated into new trapping grid; and also considering the lack of relevant predictors for mongooses presence (i.e generalist species with broad denning requirements and without distinctive preferential habitats in Mauritius apart from rivers (which are absent in EFR) and degraded forest, …). Still, it would be interesting to create a global predictive model linking a mongoose population prediction model (using current grid Timms trapping data and mongoose occurrences during predator-index) with a predictive model for the pink pigeon population in the reserve, since it's the endemic bird species which is the most likely affected by mongoose predation. As a matter of fact, it has already been attempted in the past in Mauritius by Roy in the framework of his thesis on the ecology and management of the small indian mongoose in Mauritius (Roy, 2001).

4.2.3 Goodnature A18 and Timms traps sites monitoring

One of the most efficient way to improve mongoose control strategy in the short-term in EFR would be to start using Bombay-duck fish as a bait in all Timms traps of the full trapping grid of the reserve instead of dry-salted fish; which has already been implemented since the end of the fieldwork of this study. Moreover, increasing the density of Timms traps from 1/100m to 1/75 m could be a relevant and realistically feasible increase in the trapping effort of the reserve (K. Bundhoo 2023, pers. communication). It would especially be crucial to target ecologically sensitive areas (i.e sites around the aviaries), areas of mongoose immigration into the reserve and other hotspots for mongoose occurrences and trapping highlighted in this study.

4.3 Recommendations for future work to carry in EFR and in Mauritius, perspectives for other invaded islands

Several perspectives for the improvement of mongoose control in Mauritius have been suggested by *Roy* (Roy, 2001); the main ones being to maximize mongoose control effort during the breeding season and to control areas surrounding core areas to limit immigration, as well as placing traps at strategic locations (e.g access points like dry riverbeds and roads) in ecologically sensitive areas. He also recommends using poison bait as a complement of trapping to control mongooses: since mongooses eat carrion, bait uptake by this species also having proven to be high (Creekmore et al., 1994) and since there isn't any risk for other mammalian species: *Pteropus niger*, a bat species being the only remaining native mammal species in Mauritius. Delivering safely those baits in accordance to their home-range size, via species-specific bait stations, is important to mitigate unintentional poisoning of non-target native species. Multi-predator species control is known to be of paramount importance to mitigate unintended risks linked to trophic perturbations caused by the removal of a predator species from an ecosystem (i.e "meso-predator" release effect), and thus ensure actual benefits for native biota (Ritchie et al., 2009). In this regard, *Roy* developed a multi-predator model to predict the effects that controlling different combinations of predator species would have on a population of *N. mayeri*. The results of this model went in the same direction: multi-predator species control being more beneficial for the Pink pigeon than single predator-species control. It highlights the importance of controlling all other predator species in EFR (i.e in complement of mongoose control), especially rats and cats, and making sure of the actual effectiveness of the current trapping grid for these species, for the benefits of all native threatened species in the reserve.

Killing introduced predators for the aim of the conservation of native species being a debatable strategy in an ethics perspective (Wallach et al., 2015), he also discussed two different alternatives to culling, to see if they could successfully be implemented in Mauritius. The first one is predator-proof fencing, an efficient tool to prevent predator species from entering small areas. This option is however very expensive to carry out and requires high maintenance. The second one is immuno-contraception, and would not be effective at mitigating mongoose impact on native fauna in Mauritius, since short-lived populations can still induce deleterious predation on threatened bird species. As a consequence, he suggests that a combination of trapping and poisoning would constitute the most viable and efficient strategy to control mongoose populations in the long-term in Mauritius. Some perspectives in line with these recommendations provided by *Roy* can be considered as part of long-term mongoose control objectives in EFR. Poisoning via toxic bait delivery stations has been discussed as an option to be used in complement of the current trapping strategy in order to improve the efficiency of mongoose control in the reserve. However, the potential risk of unintentional poisoning of threatened birds still needs to be addressed (Roy et al., 2002). Budgetary limitations alongside with the need to clear a buffer of 10m of native vegetation on each side of the fence in order to exclude *M. fascicularis*, constitute two arguments for not considering the setting of a "mongoose-proof" fencing all along EFR borders (Dr. N. Zuël 2023, pers. communication). It would be more relevant to try poisoning over large areas around Ebony Forest to create a buffer area to reduce mongoose immigration into the reserve, especially around ecologically sensitive areas.

The clues for improvements in mongoose control strategy, in EFR and in Mauritius to a broader extent, that have been developed in this work may also be useful to improve mongoose control in other oceanic islands facing the same challenges (i.e habitat loss and invasive species). It is the case for lesser-studied island ecosystems where *H. auropunctatus* is considered invasive, also causing dramatic damage to native fauna. It's particularly interesting for conservation strategies in insular ecosystems, since small Indian mongoose's "range of invasion" is currently increasing, especially under the influence of climate change (Louppe, 2020); notably expanding its range in the Balkans (Ćirović et al., 2011).

5. Conclusion

Based on the results of this study, it appears that Goodnature self-resetting A18 traps might not be an efficient tool to control mongooses in EFR with neither the currently used bait, nor the different candidate baits tested in this study. New tests are thus needed to be conducted in the near future to ensure the actual effectiveness of the already set 50ha Goodnature A18 full trapping grid at controlling mongooses in the reserve. In this regard, several approaches would be relevant to test, including new bait textures (e.g semi-liquid baits dripping out of the traps) and/or different angles for A18 trap entrances. Timms killing traps have on the other hand appeared to be an efficient tool to control mongooses in the reserve. However, the whole mongoose control strategy in EFR can't rely only on using such traps, as increasing Timms grid density induce significant time and manpower requirements, and since Timms traps still induce some issues with ethically killing juveniles (as shown with 2 examples in this study). The bait currently used with Timms traps (i.e dry-salted fish) has a poor environmental resistance: being often quickly detached and eaten by different species of predators, whereas Bombay duck fish seems to have a better environmental resistance while potentially allowing higher mongoose trapping success. It is thus recommended to fully switch from dry-salted fish to Bombay duck fish as Timms traps bait. Several hotspots of mongoose presence and trapping have been highlighted via the analysis of data already collected by EFR conservation staff over the past three years. Such hotspot areas that encompass both ecologically sensitive areas and potential mongoose immigration pathways into the reserve should be target zones where to start increasing mongoose trapping effort in the near future. Using poisonous baits via target-specific delivery stations should also be considered as a complementary tool to trapping for EFR mongoose control strategy; both within EFR trapping area and also targeting specific areas outside of EFR located around ecologically sensitive areas, in order to create buffer zones with lower mongoose densities, mitigating predation pressure on native threatened bird species.

7. Bibliography/References

Baldwin, P., 1954. Thermal tolerance of the mongoose *Herpestes auropunctatus*. Journal of Mammalogy 55, 645-647.

Barun, A., Hanson, C.C., Campbell, K.J., Simberloff, D., 2011. A review of small Indian mongoose management and eradications on islands.

Blumstein, D.T., Daniel, J.C., 2005. The loss of anti-predator behaviour following isolation on islands. Proc. R. Soc. B Biol. Sci. 272, 1663–1668. https://doi.org/10.1098/rspb.2005.3147

Cheke, A., 1987. An ecological history of Mauritius. In A.W. Diamond (ed) Studies of Mascarene Island Birds, 5-89. Cambridge University Press, Cambridge.

Ćirović, D., Raković, M., Milenković, M., Paunović, M., 2011. Small Indian Mongoose Herpestes auropunctatus (Herpestidae, Carnivora): an invasive species in Montenegro. Biol. Invasions 13, 393–399. https://doi.org/10.1007/s10530-010-9831-7

Coblentz, B.E., Coblentz, B.A., 1985. Control of the Indian Mongoose Herpestes auropunctatus on St John, US Virgin Islands. Biol. Conserv. 33, 281–288. https://doi.org/10.1016/0006-3207(85)90018-7

Côté, I.M., Sutherland, W.J., 1997. The Effectiveness of Removing Predators to Protect Bird Populations: Efectividad de la Remoción de Depredadores para Proteger Poblaciones de Aves. Conserv. Biol. 11, 395–405. https://doi.org/10.1046/j.1523-1739.1997.95410.x

Creekmore, T. E., Linhart, S. B., Corn, J. L., Whitney, M. D., Snyder, B. D. & Nettles, V. F., 1994. Field-evaluation of baits and baiting strategies for delivering oral vaccine to mongooses in Antigua, West-Indies. Journal of Wildlife Diseases 30, 497-505.

Daniel, S., 2022. Effects of exotic plants and forest restoration on the avian community at Ebony Forest, Mauritius, Master EMME internship report

Ebenhard, T., 1988 Wtrevy (Stockholm)

Ebony Forest course, “Introduction to predator control as a conservation tool”

Genovesi, P., 2007. 22 Limits and Potentialities of Eradication.

Glen, A.S., Atkinson, R., Campbell, K.J., Hagen, E., Holmes, N.D., Keitt, B.S., Parkes, J.P., Saunders, A., Sawyer, J., Torres, H., 2013. Eradicating multiple invasive species on inhabited islands: the next big step in island restoration? Biol. Invasions 15, 2589–2603. https://doi.org/10.1007/s10530-013-0495-y

Goodnature website, featured stories. 2023; https://goodnature.co.nz/featured-stories/biodiversity-around-the-world-japan

Griffiths C. and Zuël N., 2021. Ebony Forest Management Plan 2020-2025

Harper, G.A., Bunbury, N., 2015. Invasive rats on tropical islands: Their population biology and impacts on native species. Glob. Ecol. Conserv. 3, 607–627. https://doi.org/10.1016/j.gecco.2015.02.010

Hays, W.S.T., Conant, Sheila., 2007. Biology and Impacts of Pacific Island Invasive Species. 1. A Worldwide Review of Effects of the Small Indian Mongoose, *Herpestes javanicus* (Carnivora: Herpestidae). Pac. Sci. 61, 3–16. https://doi.org/10.1353/psc.2007.0006

Howald, G., Donlan, C.J., Galván, J.P., Russell, J.C., Parkes, J., Samaniego, A., Wang, Y., Veitch, D., Genovesi, P., Pascal, M., Saunders, A., Tershy, B., 2007. Invasive Rodent Eradication on Islands. Conserv. Biol. 21, 1258–1268. https://doi.org/10.1111/j.1523-1739.2007.00755.x

Howard ME, Zuercher GL, Gipson PS, Livingston TR, 2002. Efficacy of feces as an attractant for mammalian carnivores. Southwest Nat 47(3):348–352

Jones, C. G., 1988. A note on the Machabee skink with a record of predation by the lesser Indian mongoose. Royal Society of Arts and Sciences, Mauritius. 5, 130-133.

Kavanau, J. L., 1975. Influences of light on activity and phasing of carnivores. Am. Nat. 109:391–417.

King, W. B., 1985. Island birds: will the future repeat the past? In Conservation of Island Birds, vol. 3 (ed. M. P.J.), pp. 3–15. ICBP Technical Publication.

Lever, C., 1994. Naturalized Animals: the Ecology of Successfully Introduced Species. Poyser Natural History, London.

Louppe, V., Leroy, B., Herrel, A., Veron, G., 2020. The globally invasive small Indian mongoose Urva auropunctata is likely to spread with climate change. Sci. Rep. 10, 7461. https://doi.org/10.1038/s41598-020-64502-6

Louppe, V., Herrel, A., Pisanu, B., Grouard, S., Veron, G., 2021. Assessing occupancy and activity of two invasive carnivores in two Caribbean islands: implications for insular ecosystems. J. Zool. 313, 182–194. https://doi.org/10.1111/jzo.12845

Lowe S., Browne M., Boudjelas S., De Poorter M., 2000. 100 of the World's Worst Invasive Alien Species A selection from the Global Invasive Species Database, Invasive Species Specialist Group of the World Conservation Union (IUCN), 12pp.

Mittermeier, R.A., Turner, W.R., Larsen, F.W., Brooks, T.M., Gascon, C., 2011. Global Biodiversity Conservation: The Critical Role of Hotspots, in: Zachos, F.E., Habel, J.C. (Eds.), Biodiversity Hotspots. Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 3–22. https://doi.org/10.1007/978-3-642-20992-5_1

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B., Kent, J., 2000. Biodiversity hotspots for conservation priorities. Nature 403, 853–858. https://doi.org/10.1038/35002501

Nellis, D.W. and Everard, C. O. R., 1983. The biology of the mongoose in the Caribbean. Studies on the fauna of Curaçao and other Caribbean islands. Utrecht 64, 1–162.

Nogales, M., Martín, A., Tershy, B.R., Donlan, C.J., Veitch, D., Puerta, N., Wood, B., Alonso, J., 2004. A Review of Feral Cat Eradication on Islands. Conserv. Biol. 18, 310–319.

Pitt, W.C., Sugihara, R.T., Berentsen, A.R., 2015. Effect of travel distance, home range, and bait on the management of small Indian mongooses, *Herpestes auropunctatus*. Biol. Invasions 17, 1743–1759. https://doi.org/10.1007/s10530-014-0831-x

Ringler, D., Russell, J., Jaeger, A., Pinet, P., Bastien, M., Le Corre, M., 2014. Invasive rat space use on tropical islands: Implications for bait broadcast. Basic Appl. Ecol. 15, 179–186. https://doi.org/10.1016/j.baae.2014.01.005

Ritchie, E.G., Johnson, C.N., 2009. Predator interactions, mesopredator release and biodiversity conservation. Ecol. Lett. 12, 982–998. https://doi.org/10.1111/j.1461-0248.2009.01347.x

Roy, S.S., 2001. The ecology and management of the lesser Indian mongoose *Herpestes javanicus* on Mauritius.

Roy S.S., Jones CG, Harris S, 2002. An ecological basis for control of the mongoose *Herpestes javanicus* in Mauritius: is eradication possible?, in: Turning the Tide: The Eradication of Invasive Species.

Spatz, D.R., Zilliacus, K.M., Holmes, N.D., Butchart, S.H.M., Genovesi, P., Ceballos, G., Tershy, B.R., Croll, D.A., 2017. Globally threatened vertebrates on islands with invasive species. Sci. Adv. 3, e1603080. https://doi.org/10.1126/sciadv.1603080

Vinson, J. & Vinson, J.M. (1969) The saurian fauna of the Mascarene Islands. The Mauritius Institute Bulletin 6, 203-320

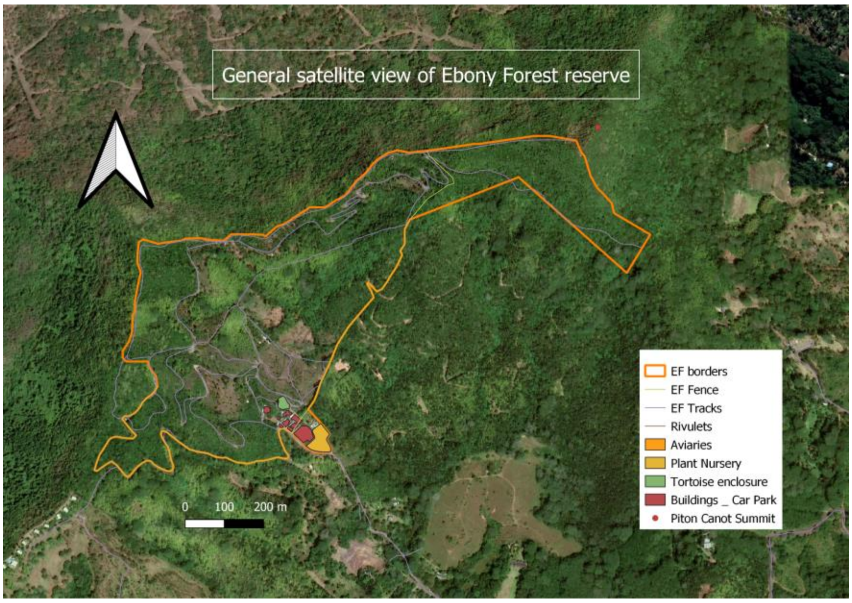
Wallach, A.D., Bekoff, M., Nelson, M.P., Ramp, D., 2015. Promoting predators and compassionate conservation: Predators and Compassionate Conservation. Conserv. Biol. 29, 1481–1484. https://doi.org/10.1111/cobi.12525

Whittaker, R.G, Fernandez-Palacios J.M, 2007. Island biogeography: ecology, evolution, and conservation, 2nd edition, Oxford University Press, Oxford. ed.

Williamson, M. (1996) Biological Invasions, Chapman & Hall

Yagihashi, T., Seki, S.-I., Nakaya, T., Nakata, K., Kotaka, N., 2021. Eradication of the mongoose is crucial for the conservation of three endemic bird species in Yambaru, Okinawa Island, Japan. Biol.Invasions23, 2249–2260.https://doi.org/10.1007/s10530-021-02503-w

8. Appendix

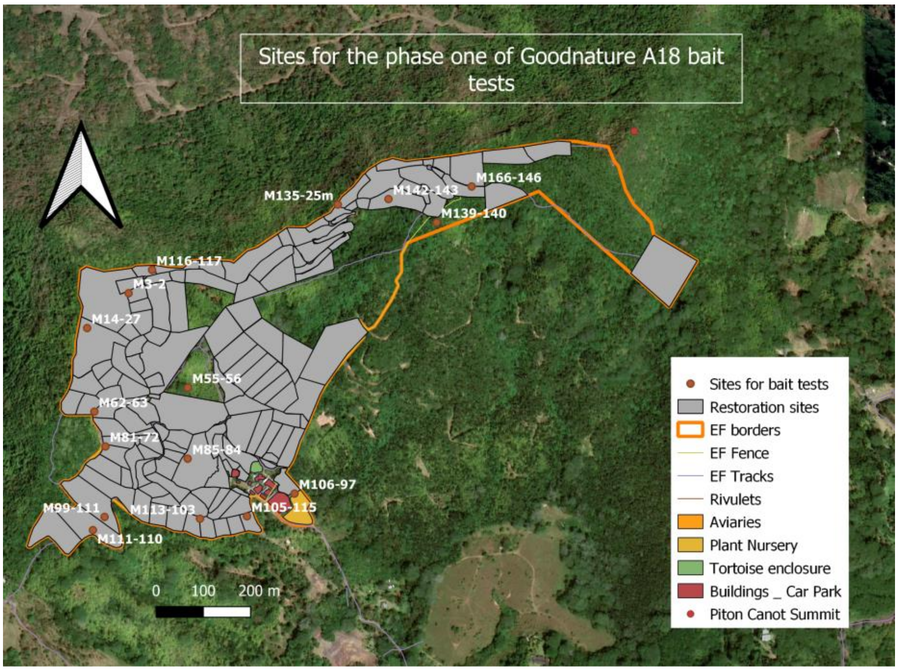


Complementary fig. 1: Map of the study site: Ebony Forest reserve, Chamarel, Mauritius

Protocole for the predator-index procedure performed in EFR:

Camera-traps were left in the field for 24h, with a dry salted-fish piece lure placed at 50cm of each camera-trap in order to increase predators' passages in front of camera-traps. It was first conducted from July 2020 to December 2022 but then stopped for logistics reasons and then started to be carried out again, starting from late March 2023. The new trapping area corresponds to the full trapping grid of EFR (i.e the whole surface of the reserve) and the new control area is located outside at the periphery of the reserve, the methodology remains the same.

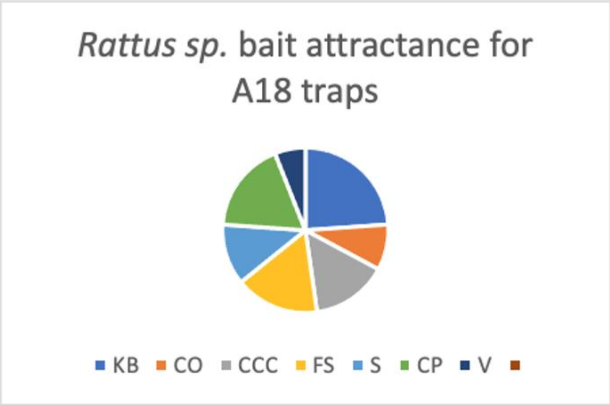
Complementary fig 2. Disposition of Goodnature A18 traps/baits and camera-trap monitoring during the phase one of bait tests



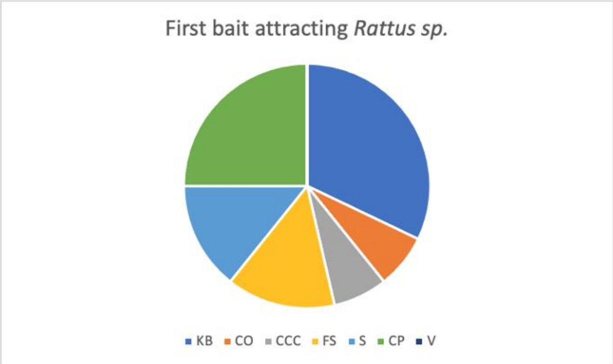
Complementary fig 3. Localisation of the different sites where Goodnature A18 baits were tested during the phase one of bait tests performed in Ebony Forest reserve. open canopy sites: M143-142 + M85-84; closed canopy sites: M113-103 + M3-2 + M166-146 + M99-111 + M62-63 + M55-56

Complementary fig. 4: Disposition of Goodnature A18 and Timms traps and camera-trap monitoring of sites where both types of traps are present in the same location

bait_type	TOTnb_attractance
KB	16
CO	6
CCC	10
FS	11
S	8
CP	12
V	4



bait_type	first_bait
KB	9
CO	2
CCC	2
FS	4
S	4
CP	7
V	0



Complementary figure 5.: Results of the attractance of candidate baits for Rattus sp. in phase one of Goodnature A18 bait tests

Remarks about Goodnature A18 candidate baits resistance to environmental conditions:

->Sardine bait: gets moldy very quickly or degraded/consumed.

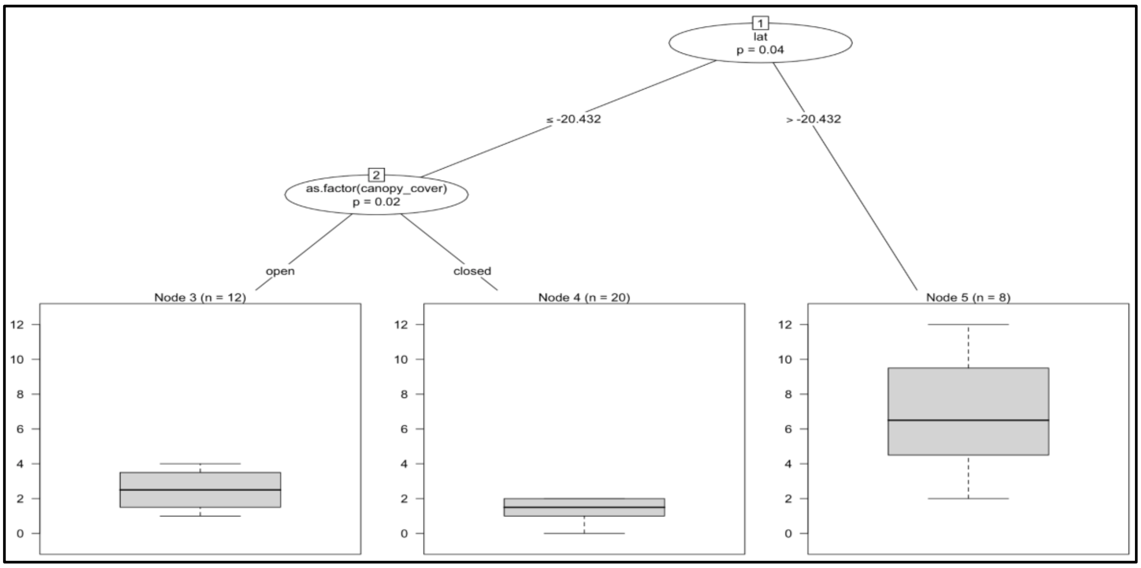
-> Coconut chew-cube: attracts a lot of ants and is quickly degraded by them

-> Cat pellets/Kentish bait: gets slightly moldy after a few weeks

-> Other candidate baits -> good resistance to environmental conditions for at least 1 month

```
> AIC(model0,model1,model2,model3,model4)
       df      AIC
model0  2 194.3534
model1  6 122.0671
model2  5 181.8427
model3  5 124.9189
model4  4 121.7228
```

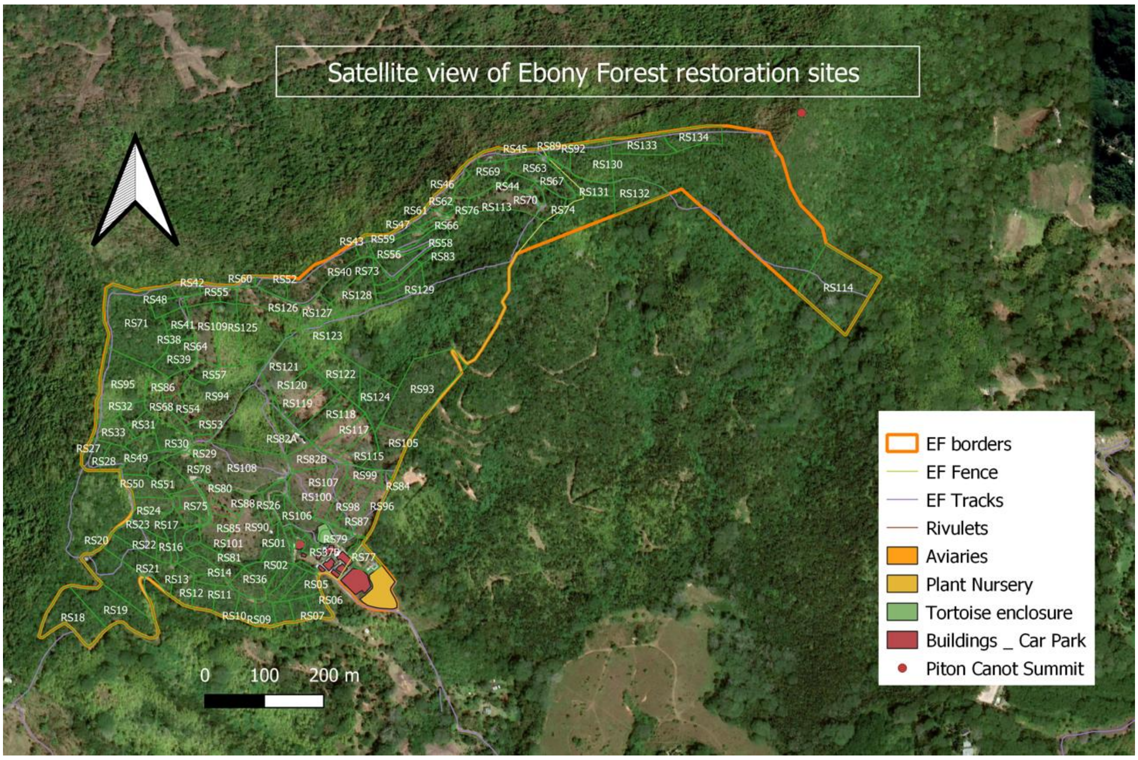
Complementary fig. 6: Summary of the comparison (using AIC) between the different models tested for data about mongoose occurrences on camera traps during predator-index



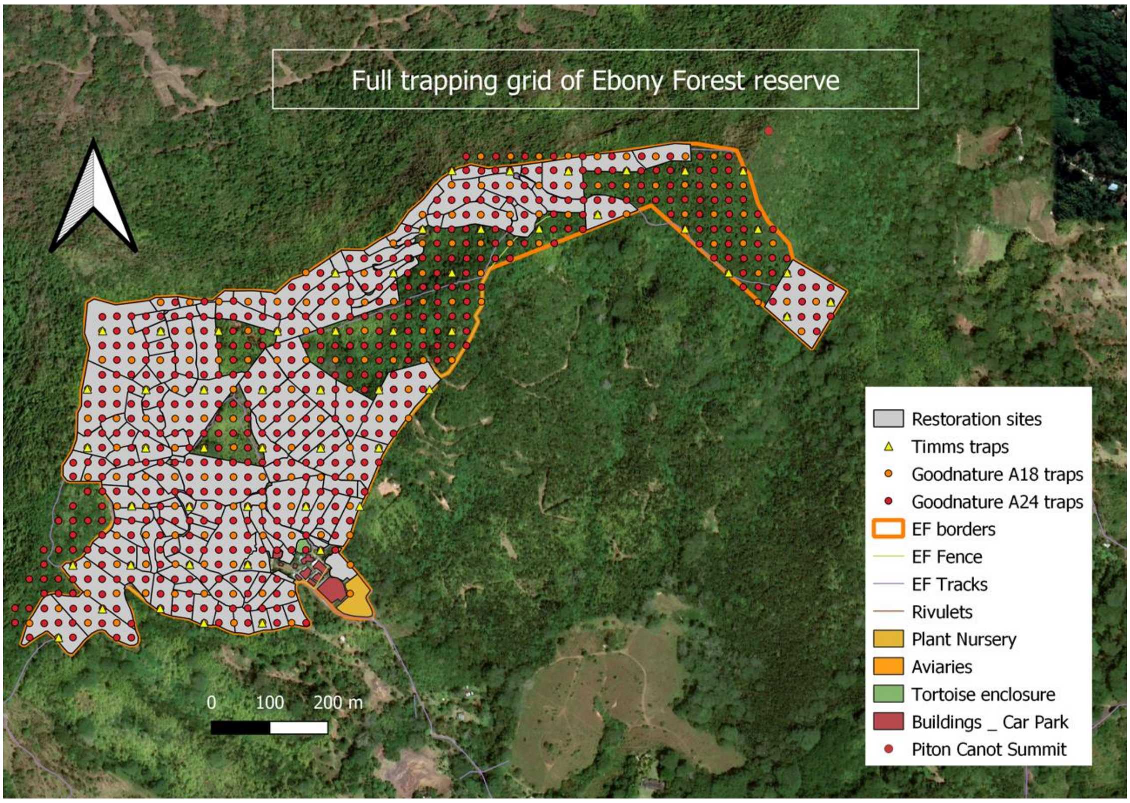
Complementary fig. 7: Results of the regression tree computed with data about mongoose occurrences on camera-traps during predator-index

```
> AIC(model0,model1,model2,model3,model4,model5,model6,model7,model8)
       df      AIC
model0  2 190.0923
model1  7 196.1930
model2  5 194.0309
model3  5 194.6884
model4  4 191.9878
model5  5 192.6785
model6  4 192.6662
model7  4 190.9136
model8  3 191.5647
>
```

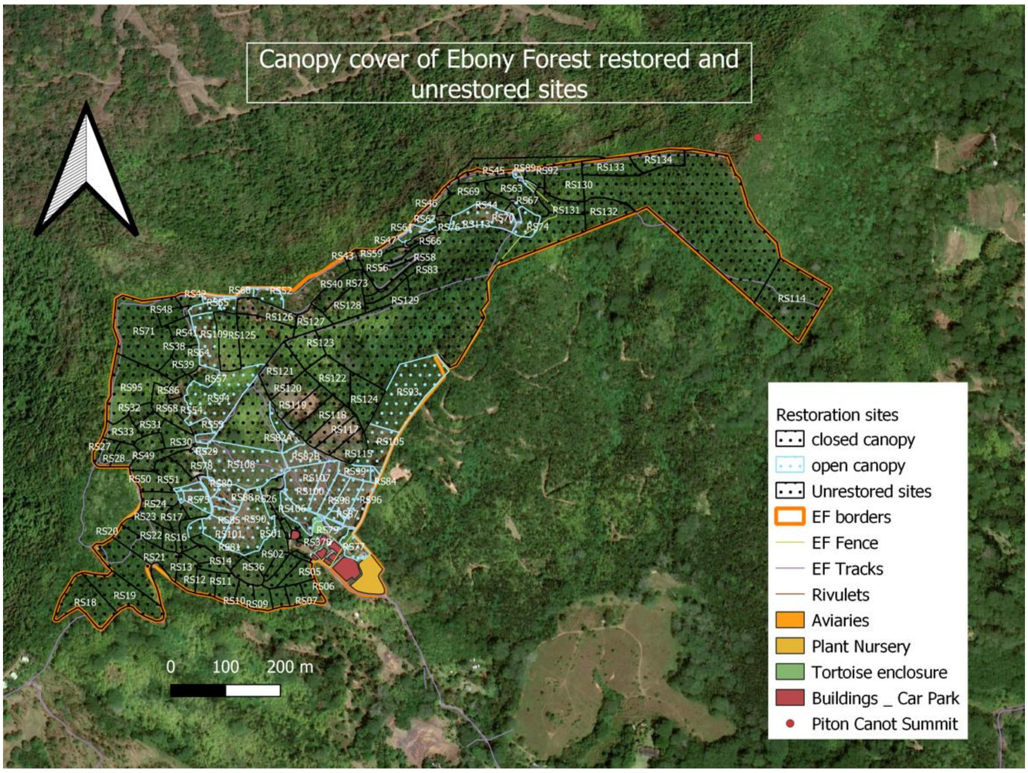
Complementary fig. 8: Summary of the comparison (using AIC) between the different models tested for data about mongoose trapping in Timms traps grid



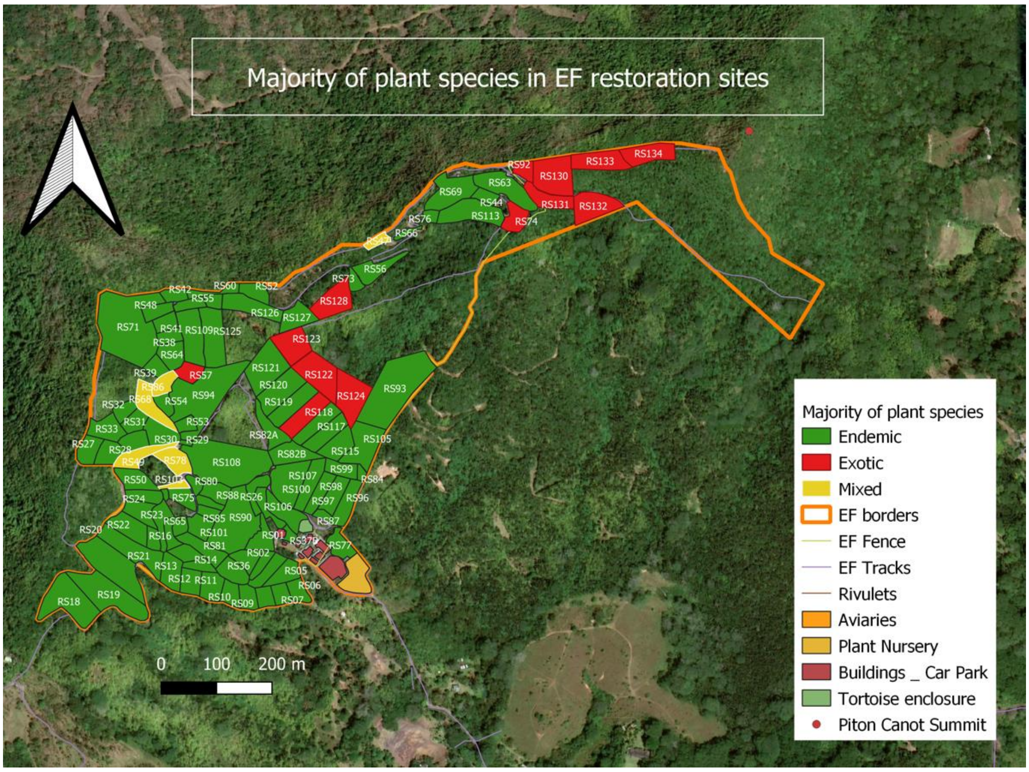
Complementary fig. 9: Satellite view of Ebony Forest restoration sites



Complementary fig. 10: Goodnature A24, A18 and Timms full trapping grid of Ebony Forest



Complementary fig 11: Canopy cover of Ebony Forest restoration sites and unrestored areas



Complementary fig 12.: Majority of plant species in Ebony Forest restoration sites

9. Abstract

Mauritius is facing dramatic biodiversity loss, mainly because of the destruction of most of its native forests, but also due to the impact of invasive alien species. Introduced mammals like rats, cats and mongooses predate on native birds, most of them now being endangered. Ebony Forest reserve is a nature reserve located in southwest Mauritius, which is home to six out of the nine endemic terrestrial bird species, including the pink pigeon (*Nesoenas mayeri*). This land bird species is particularly vulnerable to ground-based predators like the small indian mongoose (*Herpestes auropunctatus*). In this context, the general aim of this study was to improve the efficiency of mongoose control strategy in Ebony Forest reserve. It appeared that Goodnature A18 traps might not be an efficient tool to control mongooses in EFR with neither the currently used bait, nor the different candidate baits tested. New tests are thus needed to ensure the actual effectiveness of the already set Goodnature A18 trapping grid at controlling mongooses in the reserve. Timms traps have appeared to be an efficient tool to control mongooses in EFR, especially when using Bombay duck fish. Several hotspots of previous mongoose presence and trapping have been highlighted, encompassing both ecologically sensitive areas and potential mongoose immigration pathways into the reserve. These sites should be target zones where to start increasing mongoose trapping effort in the near future. Using poisonous baits should also be considered as a complementary tool to trapping, to increase the efficiency of mongoose control in the reserve.

Keywords: “Invasive alien species”, “introduced mammals”, “predator control”, “*Herpestes auropunctatus*”, “island bird conservation”

Résumé

L'île Maurice fait face à une perte conséquente de sa biodiversité, principalement en raison de la destruction de l'essentiel de ses forêts indigènes, mais aussi en raison de l'impact des espèces exotiques envahissantes. Les mammifères introduits, tels que les rats, les chats et les mangoustes, exercent de la prédation sur les oiseaux endémiques, la plupart étant désormais menacés d’extinction. Ebony Forest est une réserve naturelle située dans le sud-ouest de l'île Maurice. Elle abrite six des neuf espèces d'oiseaux terrestres endémiques de l’île, dont le pigeon rose (*Nesoenas mayeri*). Cette espèce d'oiseau terrestre est particulièrement vulnérable aux prédateurs terrestres comme la petite mangouste indienne (*Herpestes auropunctatus*). Dans ce contexte, l'objectif général de cette étude était d'améliorer l'efficacité de la stratégie de contrôle des mangoustes à Ebony Forest. Il s’avère que les pièges Goodnature A18 pourraient ne pas être un outil efficace pour contrôler les mangoustes, ni avec l'appât actuellement utilisé, ni avec les différents appâts candidats testés. De nouveaux tests sont donc nécessaires pour garantir l'efficacité réelle de la grille de piégeage Goodnature A18 déjà installée, pour contrôler les mangoustes dans la réserve. Les pièges Timms se sont quant à eux révélés efficaces, en particulier lorsqu'ils sont utilisés avec du Bomli comme appât. Plusieurs points chauds de présence et de piégeage de mangoustes ont été mis en évidence, englobant à la fois des zones écologiquement sensibles et des voies d'immigration potentielles de mangoustes dans la réserve. Ces sites devraient être des zones cibles où il faudrait commencer à augmenter l’effort de piégeage des mangoustes dans un futur proche. L'utilisation d'appâts empoisonnés devrait également être considéré comme un outil complémentaire au piégeage, afin d'augmenter l'efficacité du contrôle des mangoustes dans la réserve.

Mots-clés:
“Espèces exotiques envahissantes”, “mammifères introduits”, “contrôle des prédateurs”, “*Herpestes auropunctatus*”, “conservation d’espèces d’oiseaux insulaires”.