Madagascar Camera Trapping Protocol

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Summary of Topics:

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- ✓ Choosing a camera model
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Determining Objectives

Prior to choosing cameras or designing your study, you must first identify your primary objectives and target species. Studying the behavior of a single species, sampling an entire carnivore community, or estimating density of an individually identifiable target species would all result in using different camera models, set in different positions, and programmed to collect different types of data. For example, attempts to estimate density of a single species usually results in using two cameras per station, positioned on opposite sides of the trail, programmed to photo mode. This approach is also extremely sensitive to the distance between cameras as you must adhere to key assumptions involved with density estimation. However, surveying a community of species and estimating occupancy allows you to position only one camera per station, increase the spatial distribution of your sampling extent, focus more on a wide range of habitat types, and potentially explore additional options (ex. behavior using video). Once your target species and primary objectives are identified, your sampling design should be established, allowing you to ultimately determine minimum features required of a trail camera.

Choosing a Camera Model

Choosing an appropriate camera model will depend on its intended application. There are stark differences in abilities and reliability across models (Apps and McNutt 2018a; Apps and McNutt 2018b; Swann et al. 2011). The number and types of cameras is not only overwhelming, it is constantly changing from year to year. You should first establish what your minimum required capabilities are for a camera **(Box 1)** and then research cameras that meet those requirements. For those who may be unfamiliar or new to camera traps we outline some of the primary differences and capabilities of camera traps that you will want to consider when selecting a camera model for your study below. We highly recommend referencing Trail Cam Pro (https://www.trailcampro.com/) for the most up to date information on available trail cams. However, we also include a brief evaluation of our experience with several camera brands we have deployed in the field (Figure 1).

RECOYNX (Hyper Fire)	BROWNING (Strike Force Pro XD)	MOULTRIE	HCO SCOUTGUARD
Price Range: $400 - $1200	**Price Range:** $120- $260	**Price Range:** $60- $180	**Price Range:** $250?
PROS: - Best performance, durability & reliability - Custom orders possible - White-flash available	**PROS**: - Performance/price - High quality night & day imaging - Compact & lightweight - Built-in aiming screen	**PROS:** - Affordable price - Many features	**PROS**: - Good quality/ price - Low cost - Slow trigger speed
CONS: - Price - Can be bulky-heavy - No built-in aiming screen	**CONS:** - Battery issues in the field	**CONS:** - Low reliability: fail early and often - Poor photo quality (nighttime blur)	**CONS:** - Poor photo quality (nighttime blur) - Lower rate of species ID - No longer sold- available

Figure 1. Comparison of camera brands deployed in Madagascar under rainforest conditions in parentheses are specific models we use.

While Recoynx remains the leader in terms of performance and longevity, it remains cost prohibitive for most researchers. If few cameras are required and photo quality and long-term performance is the priority, then Recoynx may be the best option. For most camera trappers, Browning is now the most preferred manufacturer based on performance and price (TrailcamPro website). We are currently using Browning Strike Force Pro XD in the field. We had issues with a subset of cameras rapidly draining batteries; however, the company has replaced those cameras for us. Overall the quality of photos and performance of cameras currently make this brand worth the purchase.

Triggering Method: Triggered vs Non-triggered

A fundamental difference among models or modes of operation of the same model is the way in which a camera is triggered to record an image. A camera that is "non-triggered" will record images either continuously or at scheduled time intervals (often referred to as time-lapse) In contrast, a "triggered" camera will only record an image when a certain event happens, typically an animal arrives in front of the camera. The signal of the animal arriving could be based on a mechanical device (e.g., trip line or pressure plate), but more commonly the signal is an infrared light source (Swann et al. 2011). An active infrared-signal is one that a camera continuously emits a light beam from a transmitter to a receiver, such that when the signal is broken an image is recorded. A passive-signal is more commonly used, in which two adjacent sensors record a background temperature, such that when an animal walks in front of the sensors the movement and change in temperature trigger an image to be recorded. Generally, the utility of a non-triggered camera trap is when the study species or type of event being sought occurs frequently or continuous recording is required to ensure known absences (Dertien et al. 2017). Triggered camera traps are more advantageous when the event is infrequent, such as the presence of a rare species. Active-triggering works well when it is set at a specific height to detect a certain species, but can have high rates of false-triggers (Swann et al. 2011). Passive-triggering systems typically use less power and have a wider detection zone than active systems and therefore are more widely applicable for detecting species of many sizes for longer periods of time.

White Flash vs. Infrared

If your target species is nocturnal and you require individual identification, white-flash camera tend to produce high quality images that allow identifying marks and scars more reliably than infrared. However, many researchers prefer to use non-detectable infrared, and this has now become standard on most camera models. To date, it is very difficult to locate affordable high quality white-flash trail cameras ([Reconyx]() produce one for $450). We have used both white-flash and infrared; infrared has been effective for determining spot patterns on the spotted fanaloka. However, you should do research and compare image quality at night across camera models. Many cameras have additional settings (e.g. blur reduction) that may increase your image quality for individual identification but if this is a primary objective it may be worth purchasing a white-flash unit.

White-flash

Infrared- slow moving ind.

Infrared- fast moving ind.

Video vs. Photo

Almost all camera models now provide both photo and video options. However, there is a lot of disparity in what type of data are provided. Length of video, quality of video, sound options are just a few items to consider if using video options on cameras. Many cameras also have the option of providing both photo and video in a single capture by first taking a quick photo and then turning on the video when the cam is triggered. The researcher needs to consider what is most important in term of data acquisition when deciding between the two options. It is still possible to collect and enter the data similarly when using the video option; however, it is worth noting that watching, ID'ing, and entering data from video is almost always more time consuming compared to photo. Additionally, many available programs that assist with data entry by assigning tags or ID'ing species via automated system may struggle more with video compared to photo. An additional consideration when using video is the increased consumption of memory and battery life required. However, advantages of video include having a longer and more accurate capture of the species, which may aid in identifying individuals (Setiawan et al. 2018), as well as providing more useful data on the species (behavior, higher likelihood of seeing multiple individuals and/or both sides of the animal). If using scent lures or baiting, video may prove the most useful method.

Detection Circuit: Trigger speed, write time, delay time, quiet period

Cameras provide a wide range of options for a detection circuit, including trigger speed and delay period. Trigger speed refers to the amount of time between subsequent photos. Almost always, we set our cameras to take 3-5 photos per trigger. Setting to one photo per trigger will greatly save battery life and memory space; however, most triggers include the animal moving across the capture area and having multiple photos greatly increases the likelihood of getting better and more useful data. The delay period is the amount of time the camera is delayed ("rests") between subsequent triggers. Most cameras have the option of ranging from no delay (rapid fire) to up to 1-hr delay between triggers. We recommend you consider each camera and each placement individually when making this decision on delay period. Some camera stations/placements are in areas where animals and captures are extremely rare and using no or short delay periods only increases your chances of getting more, useful data. However, some cameras/stations are in areas where humans, cattle, dogs, or other common species may be moving constantly. Having a no or short delay period will result in thousands of photos that are not needed or wanted and will drain your battery/memory card. Most of our cameras are set to 3-5 photos per trigger with approximately 0-15 second delay period

Camera's also have variability in write time – the speed the camera can capture an image (s) and save to an SD card. The number of photos, photo image size and quality of the SD card all can influence the write speed and ultimately when the camera can record the next set of images. This can be important for fast moving species or when trying to capture groups are moving across the field of view.

BOX 1: When deciding which camera model to purchase for your research we recommend considering the following:

1. Do you require white or infrared flash?
2. Do you require video capability?
3. Trigger and/or non-triggered options (Time-lapse, continuous sampling, motion-triggered)
4. What is your price range?
5. Detection circuit: detection distance, trigger speed, write speed, and delay period
6. Image quality: day vs night, motion tolerance, color contrast
7. Battery life: some cameras are more efficient on fewer batteries, if you plan to operate on a shorter time period (< 3 months) it could be beneficial to go with a 6 AA battery cameras vs 8 AA. Batteries are expensive and this is an easy way to cut costs and weight.
8. Durability
9. Design (aiming screen)
10. Do I require a lock and/or lock box for the camera?

Establishing a Sampling Grid:

When establishing your camera grid, you must have a clear understanding of your study objectives and what you are attempting to survey and/or estimate. Our surveys often aim to survey an entire carnivore community to determine occupancy rates and habitat use. Therefore, we use somewhere between 20-80 camera traps spaced approximately 500 m apart and position them in all available habitat types according to their availability. Depending on your objectives this may or may not be appropriate, we provide a few resources for determining appropriate sampling according to your objectives at the end of this document, “Recommended Literature”.

Typically, the number of camera traps is determined by budget; however, researchers must consider the number of sampling sites required to have the statistical power to estimate ecological parameters of interest (e.g., Shannon et al. 2014). To increase sampling sites/stations when cameras are limited, it is possible to limit the sampling time (# of days) in order to move cameras and increase sampling sites. In other words, rather than having only 10 stations run for 2 months, it is possible to have 20 stations run 1 month. The spacing of cameras will depend on the objectives of the study and the ecological parameters of interest.

Researchers should **walk and map all available trails prior to establishing the camera grid**. This will greatly help with understanding forest accessibility and potential habitat variability, ultimately aiding in station placement including maintaining appropriate distance between cameras and keeping with habitat or other required co-variate distributions. When placing our camera grid, we utilize existing trails; typical human trails but in some cases game trails or newly cut trails, we create. By doing so we aim to increase our detection probability of carnivores who have previously been shown to utilize existing trails. However, depending on your objectives, target species, and sampling design this may not be appropriate.
Once tails are mapped, and a plan for general station locations is established, we commonly use multiple teams of researchers to place the grid, moving the process faster. However, it requires effective communication and planning to ensure camera placement is kept standardized. For our team, placing a grid of 20-50 cameras typically takes 4-7 days, but may vary greatly dependent on trail accessibility, weather, vegetation structure and sampling design. The use of GPS is crucial and using ArcGIS prior and during the establishment of the camera grid is extremely beneficial by allowing you to visualize camera stations and determine “gaps” in accordance with your objectives.

BOX 2: Establishing your sampling grid and camera set up

1. **Review objectives and necessary sampling scheme**
2. **Walk and map available trails and habitat**
3. **Identify camera station sites**
   - ⇒ Location (trail, trail type, random point)
   - ⇒ Co-variate considerations
   - ⇒ Visibility- possible field of view
4. **Determine precise camera location**
   - ⇒ Approach of target specie(s)
   - ⇒ Field of view- trail width, direction(s) and vegetation structure
   - ⇒ Vulnerability to environment (direct sunlight/ rain)
   - ⇒ Potential for wind triggers
   - ⇒ Sunrise-sunset
   - ⇒ Vulnerability to theft/damage (consider lock box and locks
   - ⇒ Ground water risk: splashing from the ground or flooding during heavy rain
5. **Set Camera**
   - ⇒ Clear vegetation and debris
   - ⇒ Aim camera
   - ⇒ Preform walk test
   - ⇒ Double check settings and field of view
   - ⇒ Trigger camera with place card

Programming cameras

Before leaving for the field to establish camera stations, our team programs the cameras while back in camp. By doing so we greatly cut down on the amount of time that a camera is open and exposed directly to rain or high humid conditions. All cameras allow you to change date, time, and camera name. We set the date, time and proper trigger speed and delay time. Each camera should allow you to adjust the sensitivity of the camera (High, Med, Low). We often choose High sensitivity, unless we know the camera will be placed in an area with high human or cattle areas. Most cameras have a host of other settings that allow you to delay the start of the camera or program what time you want a photo taken (activity period). We never use these features for our camera trapping. You should review your selected camera model manual to completely understand the features and we recommend testing settings before entering the field.

Selecting Camera Station

Top: After vegetation has been cleared from in front of the camera (red arrow).
Bottom: Image showcasing the camera positioning, cleared vegetation and view of the target species (red-tailed vontsira)

Setting up individual camera stations may vary greatly depending on your objectives. For terrestrial set up we recommend that the researchers locate an ideal location that consists of a flat trail with little to no slope. If the trail or land directly in front of the camera slopes towards or away from the camera then this significantly reduces the “capture area” and greatly decreases chances of capturing multiple, clear photos of the target species. Additionally, researchers should try to locate an open, clear area that is free of large rocks, shrubs, or other structures that might allow the animal to move behind or decrease the likelihood of triggering the camera. Once the ideal location is chosen the researcher can either locate an existing tree to attach the camera or create a post to aim the camera at a precise location. Often existing trees will have knots or buttressing roots that prevent the camera from lying flat or parallel against the trunk. In this case, you can use a machete to cut a portion of the tree to make it flat or you can use small sticks to place behind the camera to square it up and aim it straight. Alternatively, if no tree is available or existing trees are not in the precise location, our team will use a machete to cut a small, fast growing, common tree and cut the tree into two 1-2 m sections, sharpened at the end to drive these into the ground side by side and strap the camera in place aimed to the precise location.

Once the camera is positioned and aimed properly, it is important **to cut any and all vegetation** that might be positioned in the cameras focal area. If the wind blows and the vegetation moves then this will trigger the camera, resulting in countless photos of nothing, drained batteries, and a full memory card. Our team uses a machete to cut all low grass, shrub materials along the ground in front of the camera or along the trail. This minimal disturbance to the forest also attracts wildlife to this location in front of the

We will typical take a few stage images approaching the camera as we anticipate the species would to test the camera positioning.

camera and keeps wildlife in front of the camera for a longer period than they would stay without any disturbance. When placing the camera to capture native carnivores, we place our cameras very low to the ground (~10-15 cm off the ground) either perpendicular to the trail or slightly offset and aiming down the trail. We highly recommending placing the camera low to the ground rather than placing it higher on the tree and aiming downwards. By aiming the camera downwards, focusing on the center of the trail, you greatly reduce the trigger distance (i.e. animal must be much closer to trigger the camera) and cut down on the photograph field of view, thus reducing your total number and quality of photographs. Additionally, by placing low to the ground you increase your captures of co-occurring wildlife and/or prey species (ex. birds, small mammals, dogs, cats).

When establishing a camera, it can often be difficult to ensure the camera is placed or aimed in the precise location needed. Almost all cameras will also have some type of "walk/aim test" in which a red-light glows when the camera is triggered. While this is helpful it is still quite difficult to ensure the camera is positioned in the best possible location. Some camera models have a built-in screen that allows you to see directly what it captured in the image. If not, we carry either a tablet in a waterproof case or a handheld, point-and-shoot waterproof camera to the field. After conducting the walk test with the camera turned on, we then extract the SD card and visually ensure the camera is positioned in the precise location using the tablet or point-and-shoot camera.

After attaching, aiming, and double checking the camera programming, we highly recommend the researcher use a placard to trigger the camera. Our placards have the camera station name/number, camera name/number, date, and time. By including this placard for the initial trigger and all camera checks, it allows the researcher to confirm all data on the card are from the correct location and ensure that the date/time stamp are correct on each photograph. Finally, our team also places a piece of flagging on the trail just prior to reaching the camera. We record the camera station name/number and camera name/number on this flag. This is helpful when conducting camera checks as it prevents our team from standing in front of the camera and wasting valuable battery/memory life while filling out camera check data sheets.

Protocol: Collecting & organizing data

Data sheets

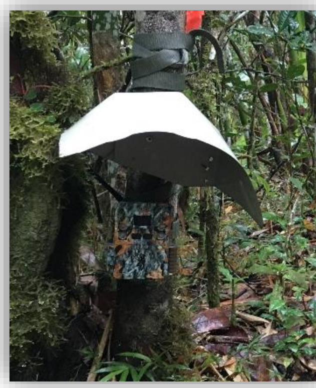
When establishing a camera station, we use the data sheet "Camera Station Set Up.". When conducting camera checks we use the data sheet "Camera Station Checking." Each of these data sheets are set up to use as a check list, thus keeping the researcher on task and diminishing the likelihood of missing a key step. Including as much data on the station during camera set up is helpful as this allows you to have more covariate data for modeling. See example data sheets provided.

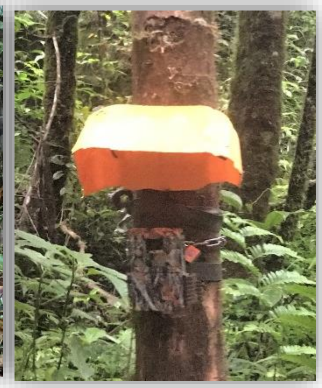
Camera Checks

During camera checks we always trigger the camera using a placard with camera station name, camera name, date, and time. Immediately after triggering the camera with placard, we open the camera, note the number of photos taken, then we shut the camera off. We remove the card and place it in some type of water proof bag or container. We do not number or name our cards. The placard prevents you from having to do this. Additionally, if you name each memory card after the camera it was placed in then you run into issues when the camera craps out and needs to be replaced. During a two-month survey we will have numerous cameras go down, require drying out, and then placed back in the field. It is the norm and not the exception for an individual camera station to have multiple different cameras placed at that location during the course of the survey. Once the card is pulled and new card is placed in the camera, we arm the camera, trigger with a placard, ensure the camera recorded the placard, then close the camera up, and move to the next.

Other Considerations

To diminish exposure of our cameras to direct rainfall and/or water sitting on top of cameras, we use either metal or plastic covers mounted above our cameras. The covers are held in place by small bungee cords. The easiest and cheapest option is simply to cut plastic jerrycan (large, yellow plastic storage container) into four pieces such that each piece creates a 90° angle where half the piece is mounted to the tree and half hangs out over the camera. Metal covers can be made in country at any major town. Jerrycans can be purchased in town or at local villages.


Metal cover


Cut jerrycan

Our team has created, printed, and laminated a "Camera Check List" that we keep in camp. This is a list of all materials needed every day to conduct camera trapping. Having and checking this list each day greatly cuts down on instances of arriving at a camera station only to find you have forgot the GPS, spare SD cards, pens, dry erase marker, extra batteries, etc.

Data Management

After arriving back from the daily camera checks we immediately sort all our gear and take all memory cards to the computer to have data uploaded. We never let memory cards sit or wait to upload the data as this exposes the card to more humidity or increases the likelihood of misplacing the card. After putting all photos in the appropriate folder(s), we then immediately back up those data on an external hard drive. After we ensure all data are backed up in at least 2 locations, we then will delete the data from the memory card and put back in the water proof sac/container to be used again.

Data Entry

A wide-range of data entry options are available. We either manually enter data into an excel photo database spreadsheet (see example provided) or we use DigiKam (https://www.digikam.org/) to tag photos and process images using the R package CamtrapR (https://cran.r-project.org/web/packages/camtrapR/index.html) in the IDE software RStudio to generate species detection records. However, there are a host of other methods depending on your primary objectives.

You should consider what information you will extract from your photos prior to beginning a systematic review. Eg. species- genera level identification, group size, behavior, categories of humans (researchers, tourist, non-tourist) For many smaller mammal's species level ID maybe impossible, thinking about classification before beginning will save valuable time later on and prevent having to re-review potentially 100,000+ images.

Recommended Gear

We provide a copy of our typical field gear purchases in country that we transport to Madagascar, in the PDF: "Madagascar Field Gear List.pdf". Most gear we highly recommend for purchase and we consider critical to operating effectively in the field. It is very difficult if not impossible to locate quality or durable gear in Madagascar. You should plan to bring everything you need. Additionally, plan that you will require extra head lamps, batteries, rain covers, rain jackets and rain pants for you and your guides.

If safety is a concern, we recommend purchasing a Garmin InReach, which allows two-way communication even to a cell phone using the Iridium satellite system. This can be extremely beneficial to check in with either a supervisor or your family while in remote areas. Safety should be a priority, entering the forest means taking a risk, likely you won't have cell service or have any way to contact help in an emergency. Plans can be purchased at a variety of price points and include emergency evacuations. (https://explore.garmin.com/en-US/inreach/)

Sample Data Sheets:

- Camera Station Set Up Datasheet.xls - initial data sheet used to record site location data
- Camera Station Check Datasheet.xls - datasheet filled during each camera station check event
- Camera Daily Gear List.docx - list of required materials and steps for conducting a station check
- Camera Station Placecard.pdf - reusable sign for station name, date, and time to be photographed before and after each station check, option to include SD card #'s for secondary ID if by chance camera station name is forgotten when programming.

Recommended Literature:

Sampling Design

(Hamel et al. 2013) Towards good practice guidance in using camera-traps in ecology: influence of sampling design on validity of ecological inferences

(Mackenzie and Royle 2005) Designing occupancy studies: general advice and allocating survey effort

Other Camera Trapping Guides

WWF Camera Trapping Guide

Studying terrestrial mammals in tropical rainforests, Leibniz Institute for Zoo and Wildlife Research

Royal Geographical Society: Expedition Field Techniques Camera Trapping

Camera Trapping: Wildlife Management and Research

Literature Cited:

Apps, P. J., & McNutt, J. W. (2018a). How camera traps work and how to work them. *African journal of ecology*, *56*(4), 702-709.

Apps, P., & McNutt, J. W. (2018b). Are camera traps fit for purpose? A rigorous, reproducible and realistic test of camera trap performance. *African journal of ecology*, *56*(4), 710-720.

Dertien, J. S., Doherty Jr, P. F., Bagley, C. F., Haddix, J. A., Brinkman, A. R., & Neipert, E. S. (2017). Evaluating dall's sheep habitat use via camera traps. *The Journal of Wildlife Management*, *81*(8), 1457-1467.

Setiawan, R., Gerber, B. D., Rahmat, U. M., Daryan, D., Firdaus, A. Y., Haryono, M., & Muhiban, M. (2018). Preventing global extinction of the Javan rhino: tsunami risk and future conservation direction. *Conservation Letters*, *11*(1), e12366.

Shannon, G., Lewis, J. S., & Gerber, B. D. (2014). Recommended survey designs for occupancy modelling using motion-activated cameras: insights from empirical wildlife data. *PeerJ*, *2*, e532.

Swann, D. E., Kawanishi, K., & Palmer, J. (2011). Evaluating types and features of camera traps in ecological studies: a guide for researchers. In *Camera traps in animal ecology* (pp. 27-43). Springer, Tokyo.