The Orion Camera System, a New Method for Deploying Camera Traps in Tree Canopy to Study Arboreal Primates and Other Mammals: A Case Study in Panama

El Sistema de Cámaras Orión, un Método Nuevo para Instalar Cámaras Trampa en el Dosel para el Estudio de Primates y Otros Mamíferos: Un Caso de Estudio en Panamá

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Resumen. Cámaras-trampa es un método muy utilizado como herramienta no invasiva en estudios ecológicos, mayormente en aves y mamíferos tropicales, desde los 1900s. Cámaras-trampa ha tenido uso en Panamá, aunque limitado al estudio de animales no arbóreos. Desde Agosto de 2010, la Fundación Pro-Conservación de los Primates Panameños (FCPP) ha implementado una nueva vía para observar primates no humanos y otros animales arbóreos utilizando "Sistema de Cámaras Orión", SCO, el cual permite instalar cámaras dentro del estrato medio del dosel sin necesidad de escalar los árboles. El método SCO elimina el riesgo para el investigador y el material utilizado es económicamente viable comparado con el equipo para subir árboles. Esta técnica ha permitido a FCPP liderar el primer estudio de largo plazo con cámaras de dosel a nivel internacional y los resultados apoyaran los planes de conservación de los primates panameños.

Palabras clave: SCO, arbóreo, mamíferos, primates, Panamá, conservación.

Abstract. Camera trapping has been a very useful and non-invasive tool in ecological studies, mainly for tropical birds and mammals, since the 1900s. Camera traps have been used in Panama, but were limited to studies on non-arboreal fauna. Since August 2010, the Fundación Pro-Conservación de los Primates Panameños (FCPP) has implemented a new way to observe non-human primates and other arboreal fauna using the "Orion Camera System" or OCS, which allows us to install camera traps within the intermediate stratum canopy without climbing trees. The OCS reduces the risk for the researcher, and the materials used are more economically viable compared to the equipment required for climbing trees. This technique allowed FCPP to lead the first long term camera trap projects in the canopy at international level, and the results will support conservation plans for Panamanian primates.

Key words: OCS, arboreal, mammals, primates, Panama, conservation.

Introduction

Use of Camera Traps Around the World

Camera traps have been used by ecologists since the early 1900 and are a non-invasive and informative method of obtaining data on animals that may otherwise be difficult to observe (Sanderson and Trolle, 2005; Kucera and Barrett, 2011). They have expanded the studies of terrestrial and arboreal fauna, especially of cryptic species that often cannot be detected by conventional methods (Rabinowitz, 1993; Schipper, 2007; O'Connell *et al*., 2011; O'Shea *et al*., 2011). Camera traps have been providing valuable information about presence/absence, behavior, and habitat use for amphibians, reptiles, birds and mammals (Kays and Allison, 2001).

Camera traps have been implemented in studies on Old World primates in Asia and Africa, where primates occupy niches from the tree-top to the terrestrial level. Thus, there is a need for an economical and safe method for installing camera traps throughout the canopy. Recent studies using camera trap methods have been useful in determining the actual distribution and efficiency of natural reserves towards the conservation of *Macaca nemestrina* and *M. fascicularis* in Borneo (Azlan and Lading, 2006). In the Lajuma Research Centre, South Africa, camera traps have been assessing mammal population surveys and seed removal studies related to the primates *Cercopithecus albogularis*, *Otolemur crassicaudatus* and *Papio ursinus*, among other mammals (Seufert *et al*., 2009). Camera traps may also opportunistically capture valuable information that can be shared among conservationists, such as the habitat use of *Macaca nemestrina* (from a study on Sumatran tigers) (O'Brien *et al*., 2003). In 2010, camera traps monitoring a mammal community in the understory of Shenzhen National Forest Park helped to evaluate management plans and corridor effectiveness for *Macaca mulatta* (Kurtis *et al*., 2010). Camera traps have provided data on biogeography, circadian activity, and geophagy in South African *Papio cynocephalus ursinus* (Pebsworth *et al*., 2011). Gray and Phan (2011) published important results obtained from camera traps about conservation effectiveness in large mammals, including *Macaca nemestrina*, from the Phnom Prich Wildlife Sanctuary in Cambodia. In Ghana, camera traps have been used to assess the remaining populations of endangered *Piliocolobus badius*, *Cercopithecus diana*, and *Cercocebus atys* (Buzzard and Parker, 2012). Recently, camera traps in Nakai-Nam Theun National Park in Laos have been used to study the co-existence of *Macaca arctoides*, *M. assamensis*, *M. leonina*, and *M. mulatta*, and to model niche differentiation (Coudrat and Nekaris, 2013). Despite these success stories, Magintan *et al*. (2010) were unable to capture photographs of *Hylobates lar* and *H. agilis* in Sumatra, which exist higher in the canopy, and they used understory camera traps.

New World primates, which are mostly arboreal, are underrepresented in studies using camera traps, because camera height has been limited to no more than three meters; though some have been successful by using plateau structures and using climbing techniques at higher elevation but for short periods. In Brazil, cameras have been used to measure social structure, behavior, and presence of *Callithrix kuhlii*, *C. penicillata*, *C. geoffroyi*, *Cebus xanthosternus*, and *Leonthopitechus chrysomelas* (Kierulff *et al*., 2004). Blake *et al*. (2010) assessed the conservation status of mammal species in Tiputini Biodiversity Station in Ecuador, including specific data on geophagy and circadian activity in *Ateles belzebuth* and *Alouatta seniculus*. Recently, camera traps in Peru have been observing the use of canopy bridges by *Saguinus imperator* and other mammal species; additionally, there are many other arboreal mammal diversity projects in Panama, Peru, Suriname, and Ecuador using camera traps where eventually could capture *Cebus apella*, *Saguinus imperator,* and *S. fuscicollis* (Tobler *et al*., 2008; O'Shea *et al*., 2011; Gregory *et al.,* 2014).

A Case Study in Panama

In Panama, Chapman (1929) started the first study with understory camera traps on Barro Colorado Island, then again for the same area in 1994, to calculate the diversity and population of mammals on the biggest island in the Panama Canal (Moreno and Giacalone, 2006; Moreno *et al*., 2006b; Kays *et al*., 2011; Moreno *et al*., 2012). At the end of the 1990s, the first long term camera trap study took place within Panama to determine the distribution of jaguar (*Panthera onca*); the study also is actually collecting important information about mammal diversity, distribution, density and habitat use in Panama (Moreno and Olmos, 2008; Moreno and Bustamante, 2009).

Panama has been improving the knowledge of its terrestrial mammals' actual distribution by using camera traps, but still lacks information for arboreal fauna. Panama is the most diverse country in Mesoamerica with respect to Neotropical primates (Rylands *et al*., 2006; Boubli *et al*., 2012): there are night species (14 subspecies), eight of them diurnal and one nocturnal. Because they are all arboreal, the use of camera traps is a good tool to complement information related to their biology and behavior in future studies and conservation practices (Méndez-Carvajal pers. obs.). In Panama, primates inhabit several kinds of forest, including mangroves, dry tropical forest, tropical rainforest, and pre-montane forest (Méndez, 1970), also due to primates' behavioral plasticity, wild primates are also found living in patches of forest, gallery forest and living fences (Méndez-Carvajal, 2011).

The Need for a New Technique to Reach the Canopy

Using arboreal camera traps in Panama will require an easy and practical method to reach the canopy to deploy surveillance devices at the right position, so primates can be recorded and photographed. Overall, a method is required that can reach the average of the intermediate stratum of forest which is between 15-20 m, with equipment that can be available to use in the field.

One of the reasons that camera traps do not tend to be used in the canopy is the difficulty and risk that scientists are exposed to when installing these devices. For climbers, it is important to put safety first during tree climbing, as risks in this method are high: there should always be another person present with knowledge of professional tree climbing, as well as rescue personnel to aid anyone in the event of an emergency in the canopy (Whitacre, 1981). The tree climbing procedure needs to be followed not only when installing, but also when taking down cameras for maintenance or change of battery and memory cards, or when cleaning away spider webs or ants, that if not removed could interfere with the camera's sensor function (Mohd-Azlan, 2009). Therefore, the risks of tree climbing are present throughout the course of study.

Secondly, a large amount of specialized equipment is needed, including but not limited to: at least four locking carabineers, two harnesses, a belay device such as a Gri-Gri or ATC, dynamic and static ropes, ascenders, Personal Anchor Systems/Daisy chains, and nylon webbing for equalizing anchors, as needed. It can be hard to find this kind of climbing equipment in tropical countries and it is expensive (Perry, 1978; Houle *et al*., 2004). A second set of ropes should be installed as a rescue rope-line in case the climber gets dizzy at the top of the tree, attacked by bees or wasps, or anything similar.

Since August 2010, the FCPP has implemented a new method, the "Orion Camera System" or OCS, to observe non-human primates using camera traps in the intermediate stratum of forest, without incurring the risks and cost of tree climbing. An additional benefit of OCS is that it is easy to adjust from the ground. The intermediate stratum has large branches where primates (and other arboreal or censorial animals) perch and pass from one tree to another (O'Connell *et al*., 2011; Olson *et al*., 2012). The OCS cameras take views of the animal in a parallel plane rather than vertical, so the range of capture is six meters or more from the camera; thus the capacity of detection is better than traditional camera-trap methods.

FCPP started a long-term project monitoring habitat use of non-human primates in four locations in Panama using OCS. This monitoring program has primarily focused on: Mantled howler monkey (*Alouatta palliata palliata*), Equatorian howler monkey (*A. p. aequatorialis*), Azuero howler monkey (*A. coibensis trabeata*), Coiba howler monkey (*A. c. coibensis*), Panamanian Black spider monkey (*Ateles fusciceps rufiventris*), Azuero spider monkey (*A. geoffroyi azuerensis*), capuchin monkey (*Cebus imitator*, *C. capucinus*), Chiriqui's Squirrel monkey (*Saimiri oerstedii oerstedii*), Costa Rican Squirrel monkey (*S. o. citrinellus*) Geoffroy's Tamarin (*Saguinus geoffroyi*) and Panamanian owl monkey (*Aotus zonalis*).

The main objective of this project is to monitor primate populations, confirm presence/absence of arboreal fauna in Panama, and detect strategic places to deploy camera traps for long periods, so we can improve the information of primate actual distribution, behavior, habitat use and conservation status. The OCS will be tested for feasibility for tracking arboreal mammals. Moreover, this information will be important to obtain comparable data that could help the Environmental Authority of Panama (ANAM) and FCPP to conserve primate populations in deforested and protected areas within the country. OCS will surely increase the information about Panamanian primates, and as a case study, it will facilitate studies of primates and arboreal mammals in other parts of the world.

Material and Methods

Study Areas

Were placed 13 camera traps in six areas within Panama: the Corpachi Trail in Limones, a protected area with humid tropical forests (Miranda-Jiménez and Méndez-Carvajal, 2012); the Amelia Farm, Jaramillo Arriba; Boquete in a shadow coffee plantation in highlands up to 1,461 m with pre-mountain forest; at Chiriqui Province (Loría and Méndez-Carvajal, in prep.); and at La Miel from Azuero Peninsula, located in the southwest of Panama, with remnant dry tropical forest and living fences that line the principal and secondary roads (Méndez-Carvajal, 2011); Chucanti Natural Reserve, located in the Darien Province with pre-montane forest and cloudy forest (Méndez-Carvajal, 2012) (Table 1, Figure 1). Two other places where tested as a brief survey, Montijo Gulf and Bajo Chiquito, both from Veraguas and Darien provinces, respectively.

Camera Trap Model and Setting

Was mounted Bushnell® Trophy Cam™ Model 119436 digital cameras, up to the canopy at 12 m average height (Table 1); each was equipped with highly sensitive passive-infrared motion sensor (IRS), and a 4 to 8-gigabyte Secure Digital memory card and 8 extended-use AA batteries. I adjusted the infrared sensor to normal, the capture setting to the multi-image mode of three images per trigger, and the time lapse between triggers to 10-s intervals. I also programmed the date and time according to Panama Standard Time (PST), using military system from 00:00 to 24:00 h. The cameras operated continuously throughout the 24-h cycle and will operate as a long term project, but I will present here the results of three months from February to April 2013 as a random example of the method. The

Table 1. Study sites description. GPS: Global position system; Tem: Temperature; RH: Relative humidity; WS: Wind speed; DBC: Distance between cameras.

Location/ Province	Gps Coordinates	Temp °C	RH (%)	WS (m/sec)	Height (m)	Area Size (km²)	Level of Camera (m)	No. of Cameras/ DBC (*m, **km)	Primate Species Present
Long Term Sites									
Limones/ Chiriqui	N 8°5'8.1" W 82°52'13.64"	30.0	82	1.7	64	0.30	14, 16	3/500*	*A. p. palliata* *C. imitator* *S. o. oerstedii*
Boquete/ Chiriqui	N 8°47'18.2" W 82°24'44.3"	17.5	91	1.0	1,461	0.13	8	1/0	*C. imitator*
La Miel/Los Santos	N 7°32'12" W 80°17'14"	33.7	61	2.6	120	1.86	12, 16, 16, 14, 12	5/1**	*A. c. trabeata* *A. g. azuerensis* *C. imitator*
Chucanti NR/Darien	N 8°47´16.5" W 78°27´1.4"	27.0	74	1.7	1,250	3.00	18, 18, 14	3/1**	*A. p. aequatorialis* *A. f. rufiventris* *S. geoffroyi* *C. capucinus* *A. zonalis*
Short Term Sites									
Bajo Chiquito/ Darien	N 8°12'43.42" W 77°30'54.28"	29.0	75	1.7	160	1.00	16	1/0	*A. p. aequatorialis* *A. f. rufiventris* *S. geoffroyi* *C. capucinus* *A. zonalis*
Montijo/ Veraguas	N 7°53'0.01" W 81° 7'20.27"	30.0	84	1.0	1	0.10	10	1/0	*C. imitator*

cameras operated continuously throughout the 24-h cycle from February 2013 to April 2013. According to Schipper (2007), using IRS cameras is not harmful to animals since they are not scared away by the light of a flash. Weather was monitored using the Electrical Transmission Company data in Panama (ETESA in Spanish). Analysis of the results is based on number of captures per hour, per day, and per month; from the photos, we can measure patterns of activity and details of behavior to obtain percentage of time for activity. An Excel statistical program was used to analyze Central Measurement Tendency. The project is under scientific permit No. SE/A-70-14 from the Panamanian Environmental Authority (ANAM).

Development of the Orion Camera System (OCS)

Getting Ready Before Camera Deployment

The OCS is a practical and easy method for setting cameras at intermediate stratum using the following materials: a bow, an arrow, weights and fishing filament cord (30 pounds), 5 mm rope (30 m long), 11mm rope (30 m long), a hacksaw or knife, PVC (Polyvinyl chloride) pipes (1" diameter, 2 m long), PVC connectors (1" diameters), T-shaped PVC connectors (1" diameter), plastic tape, duct tape, nylon cable ties (7" long), AA batteries, Bushnell Camera. Except for the digital equipment, all items are easy to find in a

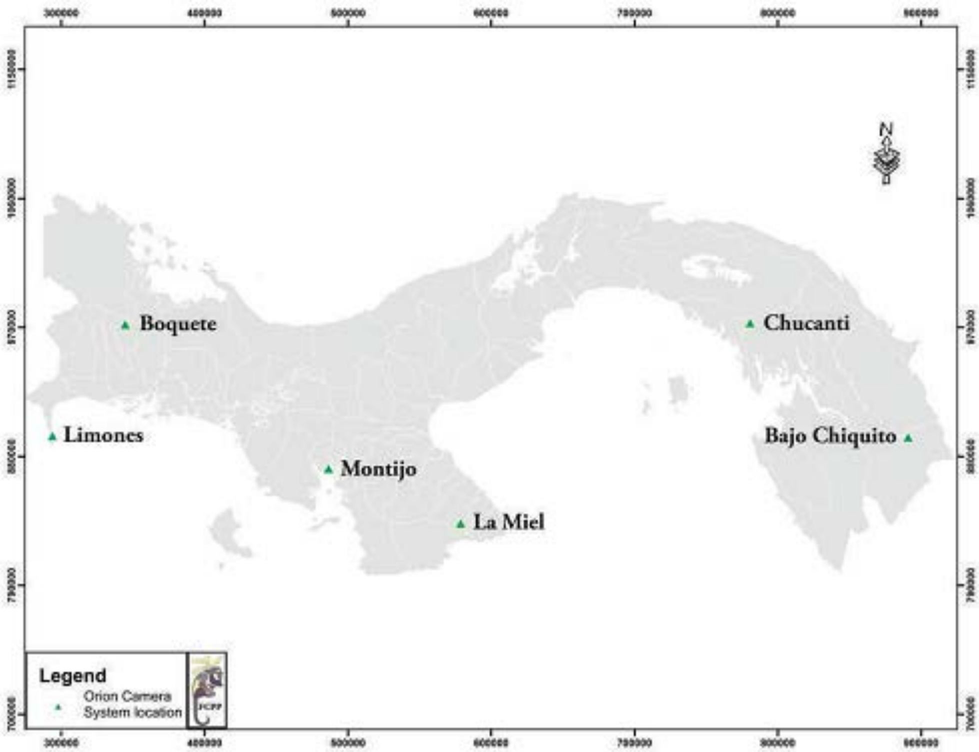

Figure 1. Location of study sites using Orion Camera System (OCS) in Panama, Central America. Map was elaborated by Jonathan González from FCPP.

hardware store, and some could be home-made. Before any installation, the PVC pipes should be painted with green and brown colors, to camouflage and keep them discreet.

Prior scouting in the area should be done in order to locate convenient places to put the camera; for our study we looked for branches that could be used by animals for support, bridges to cross between trees, or presence of trees during blooming or flowering season.

How to Set the OCS:

Using a bow and arrow with a weight attached to the tip, the researcher needs to shoot a 30 pound fishing filament rope (or nylon cord) up and over the branch that has been selected for the placement of a camera trap (Figure 2).

Once the researcher has shot the filament rope over the correct branch, the end of the rope should then be attached with a second rope of 5 mm diameter, using a knot (sheet bend or double sheet bend recommended). This knot should then be covered with plastic tape to help facilitate the ropes passing through the branches and leaves as they are hoisted up.

After the second rope has been passed over the branch and down the other side (to be held by an assistant), another rope, called the principal line, should be attached. This principal line should be at least 11 mm in diameter and the knots should again be covered with plastic tape to avoid potential resistance when passing up and over the branch (same knot recommended as in step number 2).

Then the end of the 11 mm rope held by the assistant should be tied to a tree to anchor the rope. The other end of the rope will support the camera (Figure 2).

A camera trap should then be attached to a PVC (Polyvinyl chloride) pipe measuring 1” diameter by 2 meters long (Figure 2). This is to be done by securing the loops located on the back of the camera to the PVC pipe with nylon cable ties and then covering the ties with duct-tape. Because the back of this camera model has a protruding lip near the bottom of the exterior case, it is necessary to make a small, linear groove in the pipe with a hacksaw or knife. The lip of the camera is then inserted into this groove so that the camera will lie flush with the surface of the pipe. The PVC pipe should then be affixed with a T-joint (Figure 2), in order to provide the principal pipe with the camera more stability on the branch once in place.

The T-joint has to be pre-cut along its entire length, dissecting it across its middle (once cut, the interior shape of the channel becomes a "U" instead of an "O"). This is done in order for the camera to be stabilized within its channel (Figure 2).

After being attached to the pipe, the camera's perimeter needs be sealed with duct tape in order to help waterproof it from the elements. If it is not sealed properly, moisture can enter into the interior and disrupt the camera's operation.

The principal rope line should now be threaded through the interior length of the PVC pipe. Depending on the height of the tree, the first PVC pipe will need to be attached to a second PVC pipe via a 1" diameter connector. The principal rope will then need to be threaded through this second pipe as well. With connectors, keep attaching more PVC pipes together until you reach the desired height for the camera trap (Figure 2). You will need to use approximately 7-8 PVC pipes, attached end-to-end with the principal rope threaded through the entire length, for a tree 16 meters tall. The length of the ropes used should be double the height of where you would like to place the camera.

Once the camera is in place, you will be able to adjust the direction it faces by rotating the pipes by hand from below. This will allow you to move the camera lens to the most desirable direction so that it captures photos and video of the animals you are seeking.

Finally, after reaching the top of the selected branch, for the PVC pipes to hold the camera in place, the end of the principal rope should be secured with a knot at the base of the tree or in the ground using a stick, wrapped with a rubber band to ensure stability (a bike tire-tube works well for this).

How to Review the OCS

To take camera down for changing memory cards and batteries, you will need to untie the anchor (Figure 2L), attach an extra rope (5 mm diameter) with a similar length to the sum of PVC pipes used in that specific setup using double sheet bend knot to the principal line and cover this knot with plastic tape. Then you should pull the pipes down slowly without removing the connectors. Be careful when moving down the PVC pipes, they could separate easily and cause the camera to fall abruptly and possibly break the protruding lip in the back.

Results

During the case study using the Orion Camera System in Panama, I completed a total of 232 camera trap days with 14,568 hours of surveillance, and 37,601 pictures taken for the six areas sampled. Images of 11 vertebrate species (one reptile, ten mammals) were photographed, including one marsupial, seven subspecies of primates, one arboreal frugivore-carnivore, and two rodents (Table 2).

Presence/Absence Results

The camera in Limones captured images of three species of arboreal mammals, from the five reportedly present in the area. Based on our previous surveys, Limones area has a group of ~32 individuals of Chiriqui's squirrel monkey *S. o. oerstedii*, at least two groups of mantled howler monkeys (*A. p. palliata*), a group of capuchins (*C. imitator*), two tayras (*Eira barbara*), coatimundis (*Nasua narica*) and red-tailed squirrel (*Sciurus granatensis*) (Miranda-Jiménez and Méndez-Carvajal, in prep.). From that list only two species were captured, detecting an additional species never seen before during our transect surveys, kinkajou (*Potos flavus*), an arboreal and mostly nocturnal frugivore-carnivore (Table 2).

The camera in Boquete, a highland with shadow coffee habitat, captured a pair of kinkajous *Potos flavus*, and the only species of primate seen in previous surveys in the area: capuchin monkeys (*C. imitator*) frequently use the surrounding trees (mostly "guaba" *Inga* spp.). This area, however, is connected with a continuous forest and we expect to obtain information on other mammals using the shadow coffee habitat. Species like the Mexican hairy dwarf porcupine *Sphiggurus mexicanus*, red-tailed squirrel *S. granatensis,* and the common opossum *Didelphis marsupialis* have been detected in our previous observations (Loría and Méndez-Carvajal, in prep.).

In La Miel, cameras photographed six species of vertebrates, including a reptile, the green iguana *Iguana iguana*, a marsupial, the Central American woolly opossum

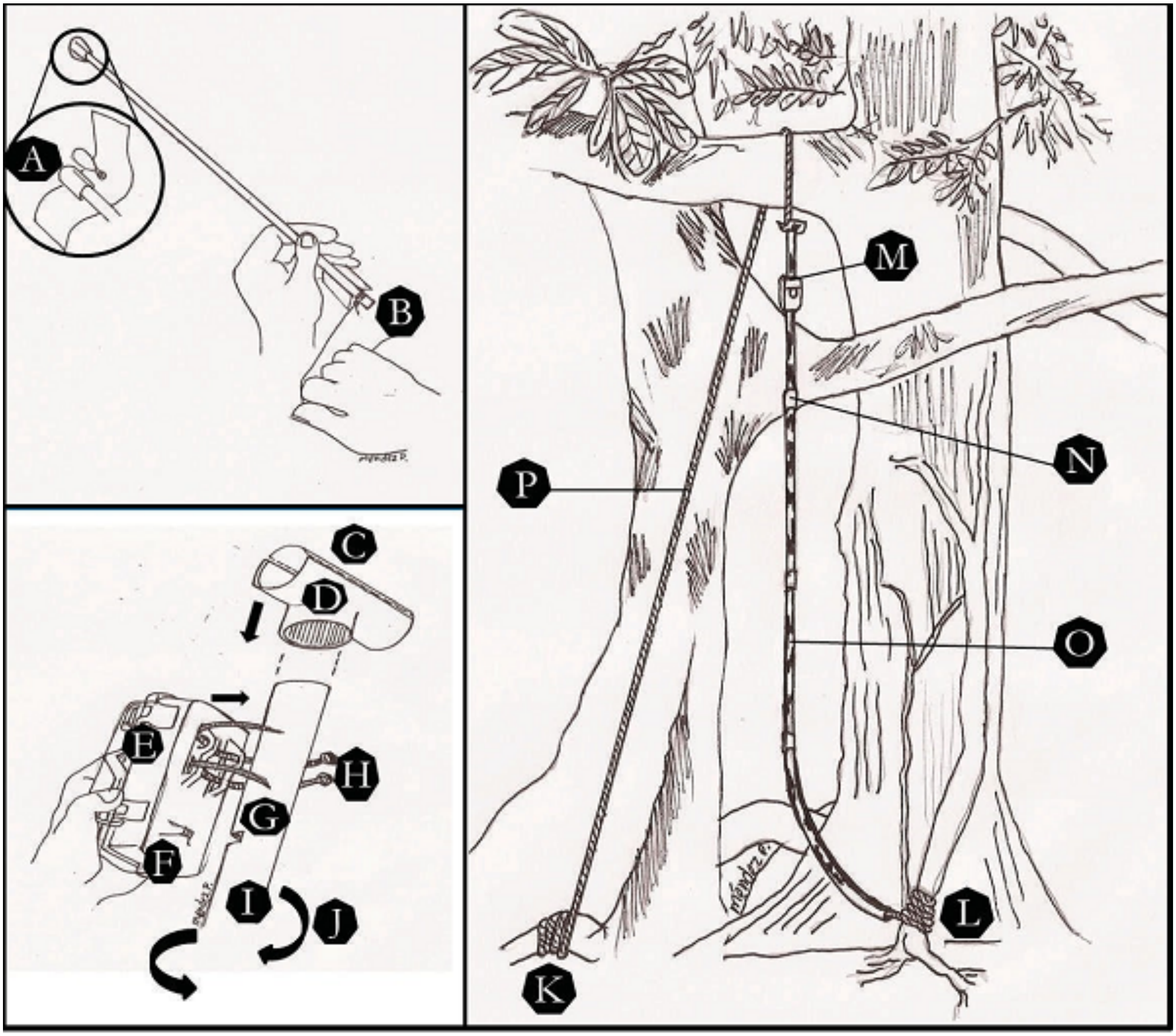

Figure 2. OCS Deployment: A) Weight should be attached to the tip of the arrow with a duct tape; B) Nylon cord should be attached to the rear of the arrow using a running knot; C) This part should be cut with a knife and top removed; D) T joint; E) Camera trap; F) Camera lip; G) Pipe groove; H) Nylon cable ties; I) PVC Pipe; J) Arrows showing the rotation that is needed to direct the lens of the camera to a branch or target location; K) Anchor of the principal rope; L) Anchor where pipes should be passed through the rope with the camera, it will be eventually removed to put down the camera, change batteries and SD card;; M) Camera trap;; N) Connector;; O) PVC pipe with camouflage paint.

Caluromys derbianus, the variegated squirrel *Sciurus variegatoides,* at least two individuals of kinkajou *P. flavus* and two species of primates, both of them endemic and Critically Endangered, the Azuero howler monkey *A. c. trabeata* and the Azuero spider monkey *A. g. azuerensis*. This area is one of the few places where the Azuero spider monkey is still alive outside the reserves, with a group ~ 25 individuals (Méndez-Carvajal, 2011); the place has been monitored since 2005 and incorporated the use of camera traps to complement information related to their behavior and use of fragmented habitat (Table 2).

Cameras in Chucanti Nature Reserve obtained images of two of the five primates living in the area, the Panamanian black spider monkey *A. f. rufiventris* (~60 individuals), and the Equatorian howler monkey *A. p. aequatorialis* (~85

Table 2. Results obtained for each study site. Number of ind.: Number of individuals photographed.

Study Site	Sampled Period (2013)	Cameras Working	Camera Trap Days (h)	Number of Species	Number of Ind.	Total Pictures	Species
Long Term Study							
Limones/Chiriqui	Feb. 18-March 12	2	23 (1,104)	0	0	26	0
				0	0	0	0
	March 12-19	2	7 (336)	1	2	100	*A. p. palliata*
				1	1	17	*Potos flavus*
	March 19-April 3	2	15 (720)	0	0	91	0
				0	0	0	0
	April 3-16	2	13 (624)	1	3	8,707	*C. imitator*
				1	3	70	*Potos flavus*
	April 16-June 4	1	49 (1,176)	0	0	10	0
Total	**3.5 months**	**1.8**	**107 (3,960)**	**3**	**9**	**9,021**	
Boquete/Chiriqui	June 2-June 6	1	4 (96)	1	3	117	*C. imitator*
La Miel, Los Santos	Feb. 20-March 16	5	24(2,880)	1	4	9,999	*Potos flavus*
				1	7	8,420	*Sciurus variegatoides*
				1	0	0	0
				1	2	59	*A. c. trabeata*
				1	2	8,896	*Potos flavus*
	March 17-May 9	4	53 (5,088)	6	28	562	*Potos flavus*
							Sciurus variegatoides
							Iguana iguana
							A. g. azuerensis
							Caluromys derbianus
							A. c. trabeata
Total	**2.5 months**	**4.5**	**77 (7,968)**	**6**	**43**	**27,936**	
Chucanti/Darien	March 4-April 4	3	31(2,232)	2	6	117	*A. p. aequatorialis*
				0	0	76	*A. f. rufiventris*
				0	0	258	0
Total	**2.5 months**	**3**	**31 (2,232)**	**2**	**6**	**451**	
Short Term Study							
Bajo Chiquito/Darien	April 3-8	1	5(120)	0	0	183	0
Montijo/Veraguas	April 18-26	1	8 (192)	1	3	10	*C. imitator*
Total	**23 days**	**2**	**13 (316)**	**1**	**3**	**193**	

individuals) (Méndez-Carvajal, 2012). The area has been monitored since 2010 to obtain information about habitat use and behavior of the Endemic and Critically Endangered Panamanian black spider monkey living in an area with more than 3 km² of protected forest. Information from camera traps in this site will help to understand changes in social structure, and group composition in a large continuous forest (Table 2).

I did not obtain any data from Bajo Chiquito; this area was included as part of a brief study to establish presence/absence in areas already impacted by humans. Bajo Chiquito is an area with large scale logging activity, according to a plan monitored by World Wildlife Fund (WWF) and executed by International Organization of Tropical Woods (IOTW). The project for sustainable use of forest from the Embera-Wounam indigenous community plans to reduce the impact of vast deforestation happening in Darien province, but there are still some effects on the fauna after removing 119 km² of forest in a selected area over time. The camera was placed in this habitat to detect any arboreal mammal using the fragmented forest but the only result obtained was a kinkajou *P. flavus*. Howler monkeys *Alouatta palliata aequatorialis* were detected by vocalizations far away from our site, though no other arboreal mammal was detected through direct observation.

The Montijo Gulf was surveyed as a part of a mammal diversity study in the area. The habitat is composed of mangroves *Avicennia germinans*, *Laguncularia racemosa,* among others. Personal observations detected arboreal mammals including the gray four eyed opossum *Philander opossum*, the brown four eyed opossum *Metachiurus nudicaudatus,* the coatimundi *Nasua narica,* and capuchin monkeys *C. imitator,* this last one captured by our camera (Table 2).

Behavior and Circadian Activity Results

For the six areas sampled, I recorded useful information to calculate habitat use rate; for this paper, camera traps were present longer at La Miel and Chucanti and therefore contribute more data. La Miel site's data from February 2013 demonstrated that *P. flavus* and *S. variegatoides* were frequent in the area and used this point almost every day (12% of use). *C. derbianus* used the habitat 6%, and pictures showed that they (and other animals) opportunistically used our OCS rope as an easy way to communicate with the canopy. For *A. c. trabeata* and *A. g. azuerensis,* both primates showed a habitat use of 3% from February 2013, but increased their presence in March and April 2013 to 16% for *A. g. azuerensis* and 12% for *A. c. trabeata*. Results obtained for *A. p. aequatorialis* and *A. f. rufiventris* from Chucanti obtained similar activity for both genera using 3% of the area (Figure 3).

Preliminary circadian activity appeared to be dominated by diurnal mammals, although species like Azuero spider monkeys showed extended range from dawn to dusk hours. For variegated squirrel *S. variegatoides,* major activity was reflected from 05:00 h until 12:00 h, with little to no activity after noon. *C. imitator*, *A. p. aequatorialis* and *A. f. rufiventris* demonstrated more activity after noon (Figure 3). Only two mammals were strictly nocturnal, those were *P. flavus* and *C. derbianus*, with activity range from 19:00 h to 05:00 h (*P. flavus*) and 00:00 h to 06:00 h (*C. derbianus*) (Figures 3 and 4). Although the period presented here is a preliminary overview for behavior activities, most of the mammals appeared to be moving; only *A. g. azuerensis* and *A. c. trabeata* were photographed resting in front of the camera (Figure 5).

Discussion

Arboreal Vertebrates Detected by OCS

Results revealed the presence of *P. flavus*, and *C. derbianus*, two arboreal mammals that were not previously detected during direct observations in two of the study sites, due to their nocturnal activity (Bucher and Huffmann, 1980; Kays, 1999) (Table 2). Three events indicated that *P. flavus* searched in front of the camera, but neither individual avoided crossing after finding these devices. *P. flavus* behavior recalls the fact that some animals may need some time to habituate to the presence of a strange object in their home range. *P. flavus* presence, from Punta Burica to Darien, confirms its actual distribution for almost in the entire country as cited by Reid (1987). *C. derbianus,* a species important for observing ancestral patterns of Primate behavior (Rasmussen, 1990), have been poorly documented in the wild (Bucher and Huffmann, 1980); the behavior captured by the camera reflected the use of limited home range and adaptations to climb using their prehensile tail, and its nocturnal activity pattern.

The use of OCS facilitated selecting a study area due to the confirmation of presence of *C. imitator* in the Boquete's coffee plantation. This study also detected an adult individual of *I. iguana* in La Miel of Azuero Peninsula. Appearances of *I. iguana* are important for management plans and conservation efforts in the area, considering this is a species classified as Vulnerable by Panamanian law and under CITES II category (ANAM, 1999).

Comparing study sites, results of detection suggest La Miel as the site with highest species richness (Table 2). However, the results may be skewed to indicate more activity in a fragmented forest due to reduced space available and high levels of competition for the resources compared to a continuous forest (Yunger *et al.*, 2002).

Cameras detected *A. g. azuerensis* one hour earlier and later than the regular circadian pattern reported for this species (Muñoz-Delgado *et al.*, 2004). The increased hours of activity could be related to new patterns adopted to survive in a reduced habitat in terms of food availability and space, as occurred with *Ateles hybridus* in Colombia (Abondano and Link, 2012), or as a result of climatological factors as suggested by Chaves *et al.* (2011). For the four primates found, activity levels were similar to other studies of the genus in continuous forest (Difiore and Campbell, 2007). Results of habitat use and circadian activity indicated that *A. f. rufiventris* and *A. p. aequatorialis* from Chucanti were overall more active in the afternoon, though sample size was small (0.03 ind/camera). The time of traveling from the resting site to the camera could imply they might be sleeping or traveling from distances far from the camera. Additional cameras to generate more data will confirm if the average travel distance is greater than that

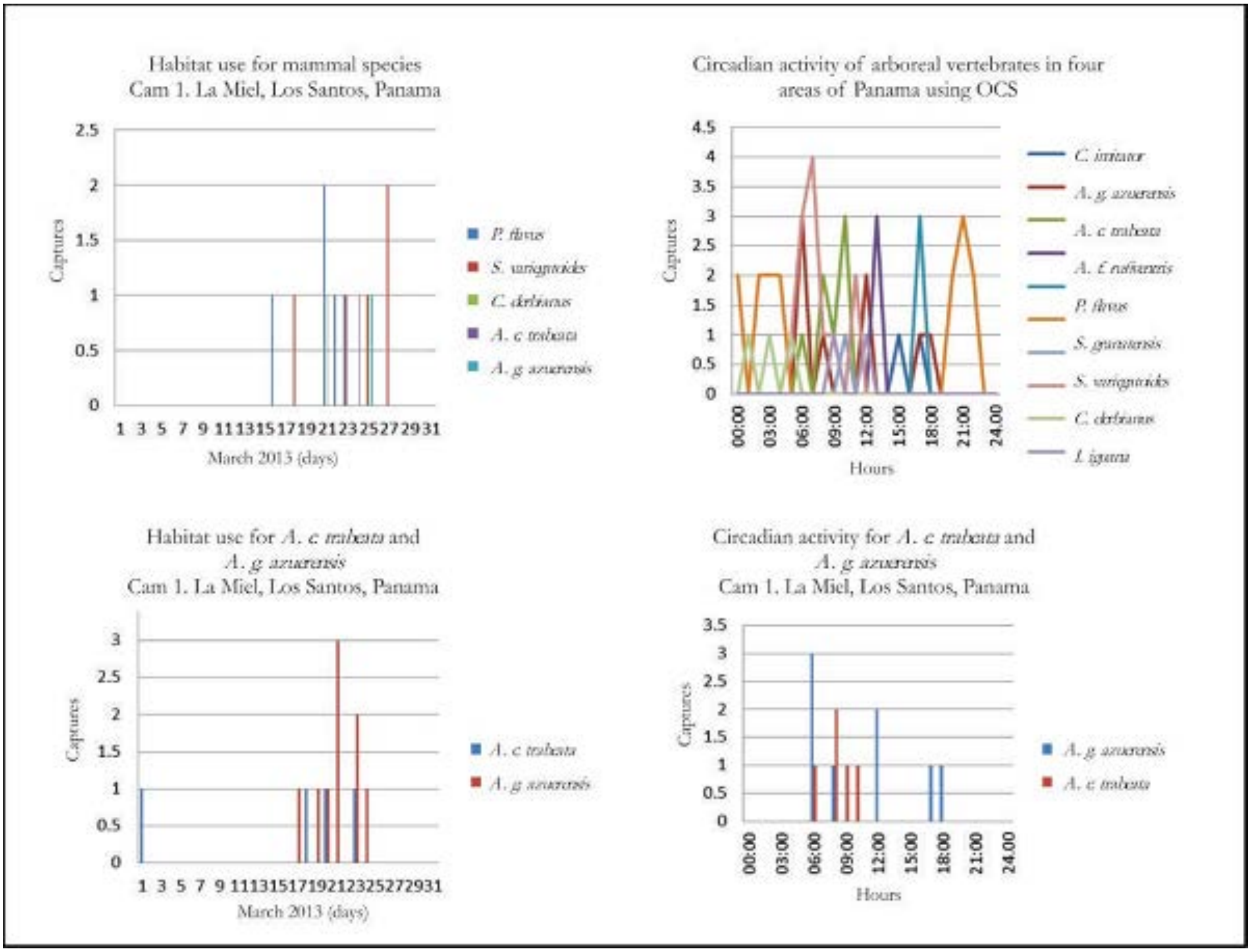

Figure 3. Data obtained for habitat use and circadian activity in primates and other arboreal fauna detected in one complete month using OCS.

obtained for *A. g. azuerensis* in a fragmented habitat. As the Chucanti forest is well connected and rainfall rate is higher than La Miel in Azuero Peninsula, I expect to find greater traveling time for *A. f. rufiventris* than for *A. g. azuerensis*, as *Ateles* feeding time is directly proportional to high average rainfall (González-Zamora *et al.*, 2011). For medium sized mammals that require more food (like monkeys), this process could be important to study how healthy primates are in living fences, patches of forest and gallery forest and how they are reacting to habitat changes (McFarland-Symington, 1988; Yunger *et al.,* 2002).

OCS Deployment: Findings and Advice

I noted two events that could be interfering in the proper function of the camera at the intermediate stratum: the camera located in front of moving leaves, and the wind speed (Figure 4). If the camera is directed to an area where leaves are exposed for an extensive time to sunlight and wind, they tend to activate the infrared sensor, falsely triggering the camera and reducing space on the memory card. This also discharges the batteries sooner. I recommend that the camera should be positioned directly in front of big branches, instead of towards foliage. If possible, position the camera towards the NE, NW, SE or SW, to avoid direct sunlight in the background. Direct sunlight behind a subject will provide too strong of a contrast in photographs, often leaving the subject in silhouette, thereby showing very little detail. The camera should ideally be located near branches that could provide access for animals to other trees.

Depending on the type of rope and batteries used and the memory card capacity, it is important to review OCS-

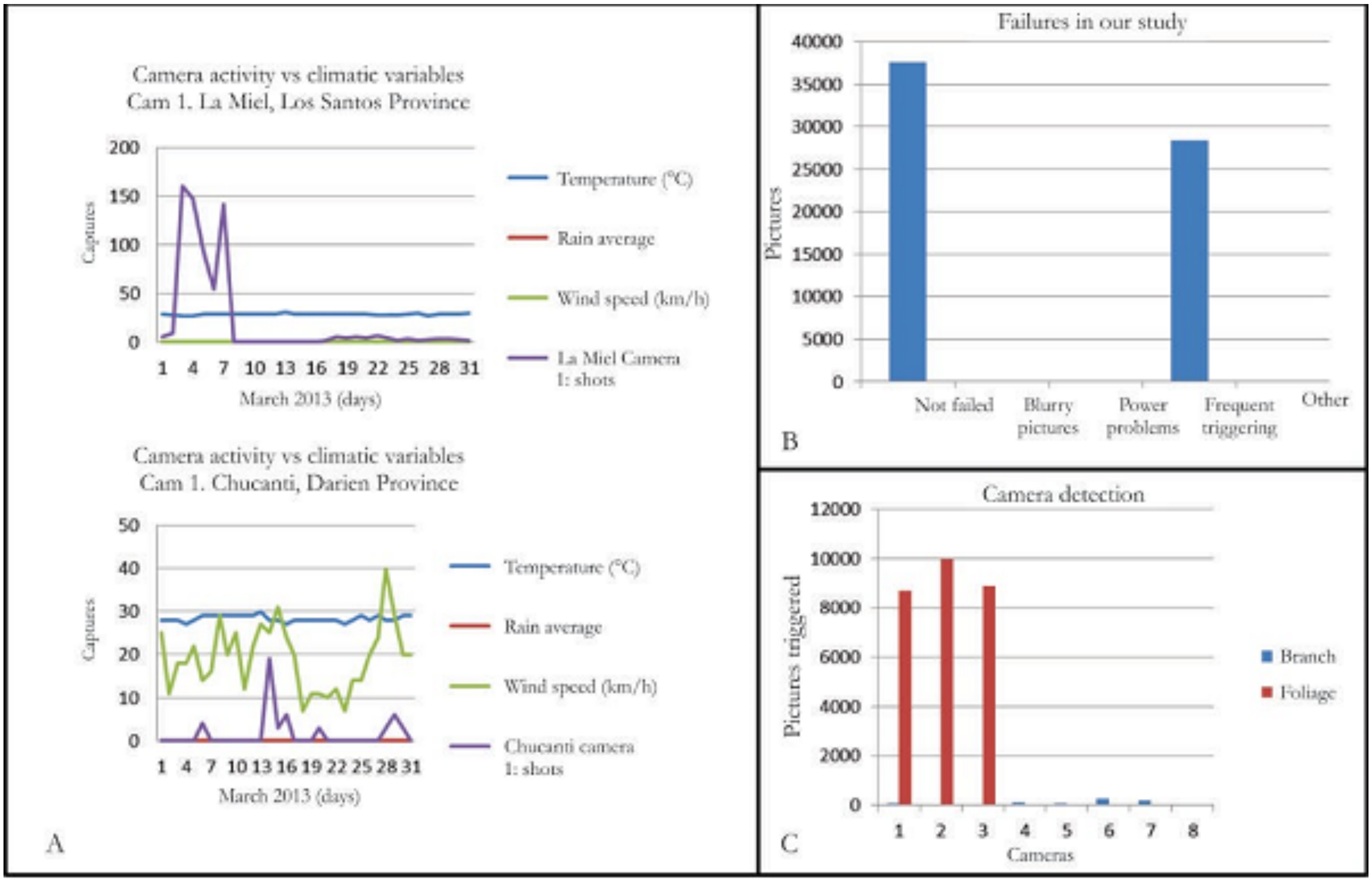

Figure 4. OCS values comparing A) Climatic variables influencing the effectiveness of the cameras;; B) Failures of the study;; C) Pictures triggered related to foliage vs branches as a potential places to set a camera.

installed cameras more often than understory camera traps. Always secure the camera trap's rope very tightly, minimizing slack. Prolonged exposure to wind and rain can cause distension of the dynamic rope, which can lead to a change in the position of the camera. Rain may also damage any adhesive material if exposed for long periods. Animals could damage the rope (although we have not experienced this in our studies), so protection of the anchor and principal line would be beneficial. Avoid anchoring the camera trap rope in places where it is easy for it to get untied and cover it for protection from the environment as much as possible. I recommend using synthetic ropes rather than natural material because they are more durable, and they do not attract termites or ants to make nests inside the OCS once the end of the PVC tubes are sealed with tape.

Memory cards should be at least 8-16 GB. It is recommended to check the cameras between 30-60 days (depending or the weather), since in the canopy, cameras will be more sensitive to movement, wind, rain, and sun damage and falling branches. We recommend placing a piece of paper inside the camera's battery chamber to secure the position of the batteries, since they can shift from strong winds in the canopy.

To conduct a camera trap survey in the canopy can be a challenge, because of locating an appropriate place to set up camera traps in order to capture photos of desired wildlife. When studying mammals in the tropics, camera traps are normally located in strategic places that are known as popular corridors used by these animals to cross between trees or to obtain food. An understory animal's path of travel and behavior can be detected by their footprints, excrement and other marks on the trails. In arboreal mammals it will depend on the plants they eat, trees they use as support and as corridors between tree tops. For quick surveys, trees in bloom or with fruits could be the best places to set camera traps at the intermediate stratum or canopy zones.

Figure 5. Primate species photographed with OCS: A) *C. imitator*, B) *A. c. trabeata*; C) *A. g. azuerensis*; D) *A. p. aequatorialis*; resting and traveling around their natural habitat.

The OCS method proves to be practical and effective in terms of target achievement (57% detection of the target; n=5; SD±1.5). The OCS is a good alternative method to deploy camera traps at the tree-top without the need to climb trees; this method is economically accessible with considerable low risk for researchers, compared with deployment methods discussed by Houle *et al.* (2004) (single rope, climbing spurs, ladder, peconha, boom, canopy raft, rope web, tower, crane, walkway tram) (for details about of OCS, see Figures 2 and 5). The process of taking down and reviewing the camera took an average of 25 minutes (n = 6) and the process of setting the camera up was 25 minutes on average (n = 6).

Conclusions

Mammal populations in arboreal stratum are difficult to observe and have been poorly documented in Panama (Kays and Allison, 2001). From our 257-264 total mammal species distributed in Panama, 45% are volant mammals, 22% are small rodents, 10% aquatic mammals, and other 10% could be endemic, fosorial or evasive to human, means that almost 87% are difficult to detect by conventional methods (Transect line, Tomahawks and mist nets). Being only 13% mammal species are able to be detected by tracks and direct observation in the field, the 12% are completely or partially arboreal, some of them ignored in Environmental Impact Studies and mammal research which means almost

30 species avoided due to the past difficulties to search the canopy. Nowadays, the use of OCS at canopy level is increasing the knowledge about our mammal diversity and behavior, reason by which I encourage other scientist to conduct research in the canopy using OCS, as this fauna is an important contributor to our ecosystem.

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