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NEW APPROACHES

A Novel Method for Capturing and Monitoring a Small Neotropical Primate, the Squirrel Monkey (*Saimiri collinsi*)

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Squirrel monkeys (genus *Saimiri*) are agile, arboreal primates that are seldom captured in the wild due to their small body size (<1 kg) and large, non-cohesive social groups (40–50 individuals). However, long-term studies on these primates often require captures and permanent identification of individuals, in order to monitor their behavior and health. Here we report on a novel trapping method successfully used to capture *Saimiri collinsi*, in Eastern Amazonia, Brazil. Our objective was to capture as many individuals as possible from one social group of approximately 50 individuals, ranging over 150 ha of *terra firme* forest. Captures occurred in November and December 2013. We habituated animals to feed on a large platform located in a 123.5 m^2 area enclosed by a green net (3 m high). Multiple individuals could freely enter and exit the area via four ropes affixed from surrounding trees to the platform. Once individuals were feeding inside the netted area on selected trapping days, the ropes were dropped remotely, eliminating their escape routes. We successfully trapped 21 different individuals of the social group (14 adults and 7 immatures) with this method. We conclude that this is a conceptually simple, effective method for trapping squirrel monkeys in most habitats, and possibly other small arboreal primates that live in large social groups. The present method was more effective than previous methods utilized to capture squirrel monkeys in the field, and has the advantages of: allowing for safe capture of several individuals simultaneously; enabling re-captures; releasing of animals as a group at the site of capture; use of soft netting which facilitates safe capture of the monkeys. Am. J. Primatol. 77:239–245, 2015.

Key words: *Saimiri*; trapping; social group

INTRODUCTION

Ecological studies on primates, particularly longitudinal studies, often depend on the permanent identification of individuals in social groups. For small, arboreal primates (<1 kg) this is an especially challenging task due to the difficulty of recognizing individuals via natural markings. Therefore, capture of these primates becomes necessary [e.g., *Aotus*; Fernandez-Duque and Rotundo, 2003]. Due to their small body size, captures utilizing darts, an approach commonly used for larger primates [e.g., *Alouatta, Cebus, Ateles:* Glander et al., 1991; *Pithecia*: Di Fiore et al., 2007] are usually unfeasible [but see Diaz-Muñoz, 2011]. An additional challenge for individual identification is presented by small primates that also live in large social groups (>20 animals), because recognizing animals via natural markings becomes even less feasible. Although capturing the primates offers a solution, trapping all or most of the individuals in a social group can be extremely time consuming.

Squirrel monkeys (genus *Saimiri*) are agile neotropical primates that present both challenges—small body size and large social groups. These primates weigh 600–900 g [Smith and Jungers, 1997] and live in

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groups of 25–75 individuals composed of adult males, adult females, and immatures [Zimbler-DeLorenzo and Stone, 2011]. Perhaps as a consequence of these two factors, squirrel monkeys are seldom captured in field studies. In fact, very little information exists in the published literature regarding capture methods for squirrel monkeys. Nevertheless, a real need exists to capture these primates, as field studies on their ecology would be enhanced greatly by this approach. For instance, individual recognition is important for social behavior studies on squirrel monkeys, which are still few [Zimbler-DeLorenzo and Stone, 2011]. In addition, as they have large home ranges (up to 250 ha; Mitchell et al., 1991) and large day ranges (up to 5 km/day; Terborgh 1983; Mitchell, 1990), placing radio collars on one or two adults can be very useful for locating and following a group [Montague, 2011] and for determining accurate ranging patterns of groups. Finally, in addition to individual marking of animals, capture makes it possible to collect data that allow us to monitor the health of the group or the population (e.g., parasite load), as well as data that complement behavioral studies (e.g., collection of blood or hair samples for hormonal assays and DNA extraction).

Previous trapping efforts with the genus have showed mixed success. The following methods have been used to trap squirrel monkeys: remote anesthetization via darting [*Saimiri boliviensis*; Mitchell, 1990], Tomahawk traps [*S. boliviensis*; Mitchell, 1990; Scollay, 1980]; or a multiple-compartment trap [Garber et al., 1993; Savage et al., 1993] developed for callitrichines [*Saimiri collinsi*; P. Castro, unpublished data]. Due to multiple factors such agility, large group size, and lack of group cohesion, none of these methods has been effective at trapping a large number of animals from one social group. Better success has been achieved with a "large cage" approach (2 m × 2 m × 3 m), similar to that used by Rocha et al. [2007] for capturing *Sapajus nigritus* in the Atlantic forest. Squirrel monkeys are more likely to enter this trap, which also permits the capture of several individuals at once, optimizing each trapping event. This method has been used by Mitchell [1990] to trap *S. boliviensis* in Peru and by our team to trap *S. collinsi* in Brazil, in 2012. But although we found this approach to be an improvement over small traps, we still found it ineffective, as we were only able to trap nine individuals from one social group over 2 months. Thus, we concluded that some modification of this method was needed. In addition, we noticed that all captures occurred within the first 8 days and animals never returned to the cage after day 8. We therefore also concluded that it is important to capture the maximum number of individuals within the first few days, because the group learns to avoid the trap after that period.

In parallel, a different capture approach was utilized in 2003 by one of the authors (P. Castro) to trap several individuals of two social groups of *S. collinsi* on the island of Marajó (Pará, Brazil). The purpose of this trapping expedition was to remove approximately 50 squirrel monkeys from the island and transport them to the Centro Nacional de Primatas in Belém, Pará to join the captive colony. In this habitat, "forest islands" occur, such that the monkeys often need to cross gaps in the forest to travel from one vegetation patch to another. Taking advantage of this habitat configuration, the team placed a large fishing net (approximately 2 m high) in the path of the monkeys and removed natural vegetation bridges when they approached a crossing area. Attempting to cross, the monkeys would then get tangled in the net and then were manually collected and placed in individual cages. A total of 44 squirrel monkeys were captured in three trapping events with this approach. What is interesting is that the monkeys did not attempt to "scale over the net" once they encountered the physical barrier, but rather repeatedly tried to cross through it, thus getting tangled and facilitating removal by the researchers.

The collection of these field experiences led us to conclude that the ideal system for trapping a social group of *Saimiri* would have the following characteristics: (a) include a large trapping structure to simulate a natural feeding area; (b) include a large trapping area in order to trap as many individuals simultaneously before the group learned to avoid the trap; and (c) use a net rather than a traditional wire cage to enclose the capture area so that the animals would remain near the ground when trying to escape (and also not hurt themselves). Here we present a trapping procedure that included these three elements, and was successful at trapping nearly half of the individuals in one social group of *Saimiri* in Brazil.

METHODS

Study Area and Study Animals

This study was conducted in the village of Ananim (VA), municipality of Peixe-Boi, 150 km east of Belém, Brazil (01° 11′ S, 47° 19′ W). The 800 ha site consists of privately owned properties that include *terra firme* primary forest and secondary forest. Rainfall is highly seasonal, with a wet season from January to June and a dry season from July to December. October and November correspond to the period of lowest fruit availability [Stone, 2007a]. Our trapping efforts were concentrated in November and December 2013 (November 2–December 5). Study animals belong to the newly revalidated species *S. collinsi* (Osgood, 1916) [Lavergne et al., 2010]. Mercês et al. (unpublished data) confirmed the taxonomic status of this form and delineated its geographic distribution, which encompasses the area of the present study. In addition to the squirrel monkeys, non-human primates at the site include black tamarins (*Saguinus*

ursulus), night monkeys (*Aotus infulatus*), and red-handed howlers (*Alouatta belzebul*).

Our objective was to capture as many individuals as possible from one social group of squirrel monkeys (approximately 46–50 individuals) that ranged within an area of 150 ha, in order to: (a) mark individuals with either radio collars, colored beaded collars, or hair dye for visual identification from a distance; (b) collect blood samples for genetic and hormonal analyses, for a long-term study on social and mating behavior [see Stone, 2014]; and (c) collect morphometric and physiological parameters to monitor the health of *Saimiri* in the wild. We had studied the behavioral ecology of this group since 2000 (though not continuously) and the group was semi-habituated to human observers.

Capture Model and Technique

This study, including all capture, anesthetization and recovery procedures, was approved by the Animal Care and Use Committees of Eastern Michigan University and of the Universidade Federal Rural da Amazônia. All procedures also were approved by the Brazilian organization ICMBio (permit number 32242-1). We adhered to the American Society of Primatologists principles for the ethical treatment of primates.

We first selected a potential capture area frequently visited by the monkeys that contained several trees of the palm *Attalea maripa*, a preferred food source and insect foraging substrate [Stone, 2007a], in a semicircular configuration. We built a wooden platform (2 m high × 4 m long × 1.5 m wide) in the center of the area. On September 1, 2013 we began baiting the platform with ripe bananas (approximately 20 bananas) daily at 0600 hr. The social group could freely access the platform via trees and branches surrounding the platform. We also built a 4 m high "hideout" located 5 m from the feeding platform, from which it was possible to observe the visits of the social group to the platform (we kept daily records on times of visits and number of animals visiting). Once the group began visiting the platform consistently, we introduced a series of four ropes as entrance/exit routes for the monkeys to access the platform. Each rope weighed approximately 20 kg and spanned 3–4 m in length from the tree to which it was attached to the platform. We also gradually removed some natural branch routes so that the monkeys had to use the ropes to access the platform.

After consistent use of the rope system by the monkeys, we placed a large green polypropylene net around the capture area, using the nearby *A. maripa* trees as "posts". We thus created an oval feeding/capture area of approximately 123.5 m^2 (Fig. 1A). The net was 3 m high and 45 m long. We purchased the original white net at a fishing supply store in the city of Belém, and dyed it a dark green using a dye

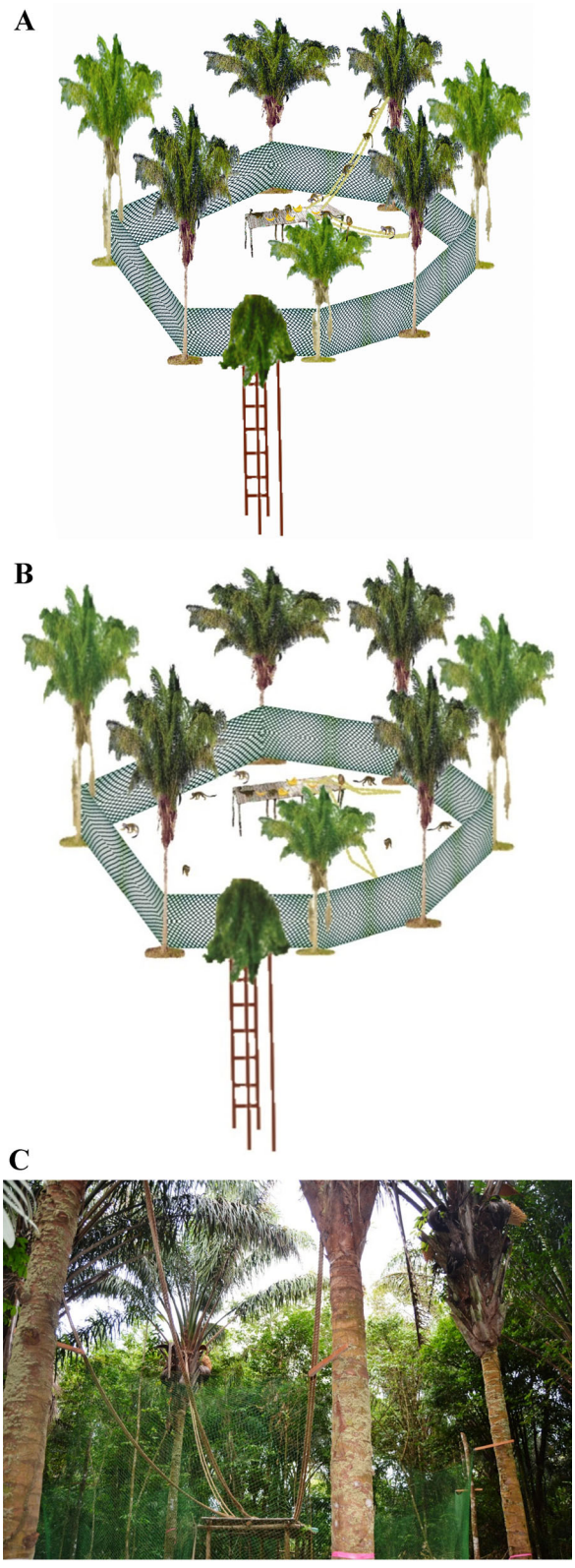

Fig. 1. Diagram for *Saimiri collinsi* capture method using oval netted area. (A) Monkeys entering and feeding in capture area before ropes are dropped. (B) Monkeys enclosed after ropes are dropped. (C) Overview of oval netted area for captures.

made for cloth (brand Guarani). The net was not pulled taut but remained a bit wobbly so that the monkeys would be unable to climb over the net once trapped (Fig. 1C). The monkeys were allowed to habituate to the netted area for 15 days before capture efforts begun. In the meantime, we observed that two of the ropes were seldom used by the monkeys, so we removed these to simplify the trapping scheme. We then devised a manual system (using a series of pulleys and nylon string to create force) by which the remaining two ropes could be dropped from the trees, from a distance, by the person in the hideout. This enabled us to eliminate the monkeys' escape routes on capture days, once a satisfactory number of individuals was in the capture area simultaneously. Monkeys would then be enclosed in the netted area (Fig. 1B; video in supplementary material). We note that since many adult females were pregnant or had newborns at the time, we never dropped a rope with an adult female on it. We always ensured that the females were feeding on the banana platform.

Captures were conducted on November 2, November 11, November 23, and December 5. The days between captures served as re-habituation days for the monkeys, when they were freely allowed to feed at the platform, just as during the habituation period. Shortly after a capture event, a field assistant entered the trap and used heavy leather gloves to individually extract animals from the net by the scruff of the neck. A second assistant then injected 1–2 ml of sweetened condensed milk into the mouth of each individual (to avoid hypoglycemia), which was then quickly placed in a wooden individual containment box (these boxes were hidden under the feeding platform and covered by palm leaves). Once all individuals were safely placed inside their containment box, we began processing animals one at a time. Animals were anesthetized with intramuscular Zoletil ® (a commercially available mixture of zolazepam and tiletamine; 5 mg/kg), given to the lower limb, either by P. Castro or F. Monteiro (both wildlife veterinarians). We weighed and obtained morphometric measurements from each animal. Adults were individually collared with a ball-and-chain identification collar with colored beads. Four individuals received radio collars (model RI-2D, Holohil Systems, Ontario, Canada). Juveniles were not collared but marked with non-toxic hair dye (Special Effects Hair Dye). All individuals were microchipped (Trovan Inc.) in the subcutaneous space between the shoulder blades. Finally, 2–3 ml of blood were obtained from the femoral vein of adults and juveniles. We also shaved a ring on the distal portion of each individual's tail, so that we could detect previously trapped animals from a distance during subsequent trapping events. After receiving subcutaneous fluids for recovery, each animal was then placed in its individual containment box with banana pieces. Once the last processed individual was fully awake and ambulatory, all individuals were released simultaneously at the site of capture.

RESULTS

The squirrel monkey group habituated within 4 days to feeding on the wooden platform. We defined habituation as more than five individuals feeding simultaneously in the trapping area, with daily consecutive visits. The group fed daily from September 3 to September 15 (when we temporarily suspended the bananas), and then again daily from October 1 until the first trapping day (November 2). The mean number of individuals simultaneously feeding inside the trap area was 13, with up to 18 individuals feeding together. Solitary individuals never came to the platform. The first individuals to arrive at the trap area were usually juveniles, followed by adult females and then adult males. Visits occurred most often between 5:45 and 6:30 am. On the day after the net was first placed, only five individuals visited, though the pattern returned to normal the following day.

Over 4 days of capture effort, we successfully trapped on all days. A total of 21 different individuals were trapped by the end of the season (Table I), with the trapping success at 5.2 individuals/event. On the first day, we captured six individuals. On the day immediately following a capture event, the monkeys avoided the platform (they remained on nearby trees but did not descend to the platform, though they returned to feeding on the second day). However, for

TABLE I. Trapping Success for One Social Group of *Saimiri collinsi* in Pará, Brazil. Average Number of Re-habituation Days Between Capture Events Was 11 Days

Day trapping occurred	Adults	Juveniles	Total
Day 1	2 females 1 male	2 females 1 male	6 individuals
Day 2	6 females 1 male		7 individuals (2 repeats)
Day 3	2 females 2 males		4 individuals (2 repeats)
Day 4	5 females 2 males	1 female 4 newborn infants (2 males and 2 females)	8 individuals (4 repeats)[a]
Total individuals			21 different individuals

[a]Although 12 monkeys were trapped on this day, in order to be conservative we do not consider the newborns as independent captures, since they were on their mothers' back.

3 days after a capture day, the number of individuals on the platform decreased to an average of four monkeys, and the speed at which they fed increased. Although 8–10 individuals would still enter the trap area at once, they did so rapidly, making it unfeasible to trap them until more days had passed. Due to this factor, the mean number of days between capture events was 11 days. During these "re-habituation" periods, the average number of daily visitors was eight individuals (range 2–16 individuals). Based on observations of tail shavings, we detected that 57% of the daily visitors had already been trapped. Marked individuals continued to revisit the trap on subsequent capture events as well (average 43% recaptures; see Table 1). One adult male captured on the first day was recaptured on the other three trapping days, but released each time.

During capture, once the ropes were dropped and the monkeys were trapped inside the netted area, they never attempted to scale the net. Rather, they remained either on the feeding platform or descended to the ground and attempted to cross the net, getting tangled in the process (see video in supplementary material). We did not observe aggression among the monkeys, or aggression towards the assistants who entered the netted area to handle the animals.

On the last day of capture (December 5), we trapped four females carrying newborn infants (under a week old). Two of those females were recaptures from November 2 (when they were pregnant) and two were novel individuals. Infants were weighed and sexed but not sedated, and were kept near their mothers during the entire processing and recovery procedure. Infants and their mothers were observed in the forest subsequently after capture and release.

DISCUSSION

In this study, we utilized a field capture method that was successful at capturing adult males, adult females, adult females with newborns and juvenile squirrel monkeys from a single social group. Darting squirrel monkeys generally is considered unsafe by many experts [E. Fernandez-Duque, pers. communication; C. Mitchell, pers. communication], not only due to their small body size but due to their high mobility and arboreality. Mitchell [1990] reported initially darting *S. boliviensis* in Peru, but abandoning this procedure due to its risks to the monkeys. Tomahawk traps also have been used to capture squirrel monkeys [e.g., *S. boliviensis*: Mitchell, 1990; Scollay, 1980; *S. collinsi*: J. S. Silva Jr., pers. observation]. In areas where *Saimiri* form mixed species associations with *Sapajus*, however, the capuchins often arrive at the traps prior to the squirrel monkeys and consume all the bait [C. Mitchell, pers. communication; see also Aguiar et al., 2007 for a similar problem when trapping howlers]. The Tomahawk approach also seems better suited for trapping a few individuals from multiple social groups for population-level studies [e.g., *S. vanzolinii*, Paim and Rabelo, unpublished data]. This is because, unlike callitrichines, *Saimiri* do not live in cohesive family groups where most individuals will eventually enter the traps [Garber et al., 1993]. Thus, this approach is not ideal when several squirrel monkeys from the same social group must be captured.

The method we present here showed three advantages over methods previously used to trap squirrel monkeys. First, a large, "natural-looking" capture area was delineated and utilized, which was successful in attracting and retaining more monkeys to feed at the baited platform. They also remained longer inside the capture area, rather than moving in and out rapidly as we found to happen when we used the large cage based on Rocha et al. [2007]. The second advantage of the large capture area was that many individuals could feed and thus be captured simultaneously, minimizing trapping events. This is important because we discovered from our 2012 trapping season that after the first few capture events, the group learns to avoid the capture area. In addition, trapping the maximum number of individuals at once avoids the probability of repeated recaptures. Even our method could not totally avoid this problem, which is often an issue with any capture method when trapping from a same social group, at the same location. Room for improvement exists, however, in maximizing the number of individuals trapped, especially on the very first trapping event. On November 2 (day 1) we trapped six individuals, which was not ideal or expected given the number of individuals visiting the platform during the baiting period (up to 18). This problem occurred not due to the mechanics of the trapping method, but from a "beginner's error" in judgment when pulling the ropes' lever. Accustomed to having 15+ individuals visiting the platform, we waited too long for a minimum of 15 individuals to be enclosed within the netted area before dropping the ropes. However, with the extra time allowed, many of the 13 individuals that were already inside left the area, with no new ones coming in. From video footage of the capture, we confirmed that 13 individuals could have been trapped, if the lever had been pulled earlier. We therefore learned not to allow too much time to pass before the ropes are dropped.

The third advantage of the method presented here was the use of the net as "trap walls" to enclose the monkeys. This approach worked very well, with the monkeys behaving as expected and not attempting to climb over the net. Rather, they attempted to repeatedly lunge towards the net and often got tangled in it, facilitating manual capture by the field assistant. We also found that the use of the soft net prevented the monkeys from being injured, as can

happen when a wire netting is used and animals are trying to escape. In fact, on the last day of trapping, we captured successfully four adult females with newborn infants, without any injury to mothers or infants.

We likely trapped a greater number of adult females (11 individuals) than adult males (two individuals) due to the high female/male ratio in *Saimiri* social groups [Stone, 2004; Montague, 2011]. For example, we know that the social group we captured contains at least 13 adult females (pers. observation). A second factor that perhaps facilitated capture of adult females is that they were approximately 3–4 months pregnant at the time (gestation length is 5 months; Garber and Leigh, 1997). Thus, the females may have been hungrier and more motivated to feed at platforms than were adult males, and may have had less mobility to climb up and down the ropes. Furthermore, during most of the year, adult males remain at the periphery of the social group [Izar et al., 2008], making them more difficult to locate and trap. We suggest that, if trapping adult males is a specific objective, the researchers simply allow additional time for adult males to arrive at the platform; when feeding on naturally occurring concentrated fruit resources, adult males often arrive in a second "wave" once adult females and juveniles have fed and left [Stone, 2007b].

We plan to continue to use this capture method annually to trap individuals from our study troops. In fact, we have reason for optimism with this method—of the two social groups monitored at the field site in 2013, we trapped the less habituated group. In 2014, we plan to repeat the trapping process with the more habituated group, which we expect will yield an even higher number of captures. The data collected with the capture now are being used to monitor the health of the squirrel monkeys at our study site (which is a highly fragmented landscape). In addition, we can now use the morphometric, hormonal, and genetic data obtained via captures in combination with behavioral data to illuminate patterns of social structure, kinship, life history, and demography. Such studies would not have been possible in the absence of data obtained with trapping, and without individually marking the monkeys.

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