CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

Behavioral Effects of Collaring on Female Black-Handed Spider Monkeys (*Ateles geoffroyi*) on Barro Colorado Island, Panamá

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By

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Abstract

The Possible Behavioral Effects of Collaring on Female Black-Handed Spider Monkeys

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In the early 1960s the advent of small radio transistors allowed researchers to remotely track animals. However, the effects of these collars on the health and or behavior of the animal(s) being studied, especially primates, have been largely unexplored. This study sought to understand if there were any significant differences in rates of grooming among collared and non-collared females. Specifically, did collared females exhibit a higher rate of auto-grooming, particularly around the collar or a lower rate of both initiating and receiving allogrooming? Over a period of 6 months (May 2012-Nov 2012) the grooming behavior of 6 collared females was compared to that of non-collared females in the single group of black-handed spider monkeys (*A. geoffroyi*) on Barro Colorado Island, Panamá. Grooming data were collected through the use of focal-animal sampling.

Chi-squared and Mann-Whitney *U* tests were conducted and the results of this study indicate that collars did not adversely influence grooming behavior. Collared females did not have a lower rate of grooming overall, and did not exhibit a higher rate of auto-grooming around the collar. Additionally, collared females did not show evidence of a decreased rate of allogrooming in either initiating or receiving compared to non-collared females. Moreover, there was no difference in the median grooming bout durations for collared and non-collared females. It is my contention that these collars do not appear to negatively influence the grooming behavior of these study animals. Also, this study highlights the need for future research regarding effects of collaring.

INTRODUCTION

In this thesis, I investigate the possible behavioral effects that collars (radio or GPS) may have on the grooming behavior of a group of black-handed spider monkeys (*Ateles geoffroyi*) on Barro Colorado Island (BCI), Panamá. Grooming among primate species is a particularly important behavior. It serves as a way to remove ectoparasites from the body but is also a very important way in which primates bond socially (Seyfarth 1983; Dunbar 1991; Pastor-Nieto 2001; Grueter et al. 2013). Literature regarding behavioral effects of attaching radio transmitters or GPS (Global Positioning System) units to wildlife populations is lacking. Most of the limited amount of research concerning this topic focuses on birds, with few studies involving mammals and even fewer pertaining to primates in comparison. The purpose of this study is to preliminarily answer the question: Do collars used to attach telemetric devices alter the behavior of black-handed spider monkeys on BCI?

A Brief History of Telemetry and Advancements in the Field

During the 1960s field biology underwent a major development due to the introduction of small radio-transistors that allowed researchers to remotely track the movements of study animals (Campbell and Sussman 1994). Without this technology it was extremely difficult, if not impossible, to collect behavioral or demographic data on "shy or elusive animals, and those too small to carry conspicuous color tags or other visible markers" (Kenward 2001a:1). Although radiotelemetry has become popular in field sciences such as primatology, ornithology, mammalogy, and conservation biology, literature regarding the investigation of possible health or behavioral effects of using this technology on the study animals is decidedly lacking. The seminal paper by William W. Cochran and Rexford D. Lord, Jr. (1963) described this burgeoning technology, and by

1989 over “2,000 tracking and biotelemetry studies have been conducted on more than 500 species” (Kalpers et al. 1989:24). Since Kalpers et al. (1989) statement, the number of wildlife studies employing these technologies has steadily increased in primatological studies (Campbell and Sussman 1994). As Cochran (1980) highlighted, the safe attachment of collars on wildlife requires both trial and error as well as extensive knowledge of the behavior and anatomy of the particular wildlife being studied, and Bleich et al. (1990) reiterate that these aspects are paramount in implementing safe methods in biological studies.

Over the last fifty years the technology used for radiotelemetry has improved significantly. The decrease in battery size required for radio-transmitters reduced the size of radio-tags, making them more viable for use in wildlife studies (Kenward 2001b). Consequently the use of radio-tags, attached by either a collar or some other method, in wildlife field studies increased during the 1980s and during this time considerable improvements were made in how data gathered through radio-tags were analyzed (Kenward 2001b). But it was during the 1990s that significant advancements were made in the technology used for radio-tagging (Kenward 2001b). A major development in the world of telemetry studies was gaining access to the global positioning system (GPS), previously reserved for military use (Kenward 2001b). In their infancy GPS tags were quite heavy, however throughout the 1990s “efforts to develop watch sized units for humans reduced the size of potential animal tags to about 30 g” (Kenward 2001b:8). This advancement allowed for more accurate data collection due to the ability of the tags or collars to store the locations of animals with data being downloaded directly from the device (Kenward 2001b). This could be done in one of three ways, first recapturing the animal or collecting a collar which has been released by a "break-away" mechanism, second the data could be transmitted and subsequently retrieved by "secondary satellite link", or third transmitting the stored data "through a local, user-controlled communication link" (Rodgers 2001:104). Kenward (2001b) made an accurate prediction when acknowledging that the increased accessibility of GPS technology and its associated data processing capabilities would play an important role in the remote tracking of animals. But in the late 1990s and 2000s there were marked improvements in the "size, cost, and performance" of GPS units that resulted in the ability to use this technology on a variety of animal species (Rodgers 2001:113). Brooks et al. (2008:527) maintain that the "precision and reliability of fix locations provided by Global Positioning System (GPS) collars have enhanced the capacity of wildlife biologists to quantify patterns of behavior, enabling a shift in the focus of telemetry research from simple home range estimation to detailed patch use, estimates of travel speed, and the breakdown of movement behavior." The authors continue by asserting that the introduction of the GPS collar has provided researchers with the ability to evaluate these behavior patterns "remotely on far ranging species moving rapidly across inaccessible terrain" (Brooks et al. 2008:527). Although the use of collars for remote tracking has become somewhat widespread in biological field studies few researchers have examined how collaring can impact study animals (White and Garrott 1990). Studies that incorporate animal marking operate under the assumption that markers (mutilations, tags and bands, and radiotransmitters) pose no threat to the study animal or that the harmful effects are negligent (Murray and Fuller 2000). Murray and Fuller (2000) assert that this "assumption of no significant marking effects is critical because it is the basis for generalizing data collected from marked individuals to unmarked animals and populations" but this theory "has not been tested rigorously for most marker types or animal species" (15).

A Review of Relevant Literature

Various studies (largely on non-primate species) have investigated the possibility that the use of collars for radio tracking can have undesirable effects on wildlife (e.g., De Mendonça 1999; Guthrie and Lusk 2004; Hamel et al. 2004; Steenhof et al. 2006; Brooks et al. 2008; Holt et al. 2009; Vandenabeele et al. 2012). Some direct and indirect negative effects have been found (Withey et al. 2001; Golabek et al. 2008), such as possible effects on sex ratio variation in water voles (*Arvicola terrestris*) resulting in litters with more males than females (Moorhouse and Macdonald 2005; Golabek et al. 2008) to possible behavioral and health effects on plains zebras (*Equus burchelli antiquorum*) (Brooks et al. 2008). Brooks et al. (2008) tested the effects of the weight of two different types of GPS collars on the rate of travel of zebras in Botswana. Although both weights they used were within the accepted limits of weight to body mass ratios, the heavier collar (0.6 percent of the total body mass of the zebra) negatively impacted the rate of travel when compared to the lighter collar (0.4 percent of the total body mass). Bleich et al. (1990) discuss various injuries that mountain sheep (*Ovis canadensis*) in California suffered due to ill-fitting collars, including severe injuries to the tissues surrounding the neck, changes in the foraging behavior, and decreased male fitness of dominant male mountain sheep (Bleich et al. 1990). Two separate studies indicated that collars could potentially negatively impact the body mass of kit foxes (*Vulpes macrotis mutica*) (Cypher 1997) and locomotor skills of iguana hatchlings (*Iguana iguana*) (Knapp and Abarca 2009), and that great care should be taken to find the correct collar to body mass ratio for the animal being studied. In addition, understanding that collaring animals at times of high stress could have a negative impact on the study animal is imperative (Cypher 1997; Knapp and Abarca 2009).

Although it has been shown that collars can negatively impact the behavior or health of an animal subject, there is the possibility that collars have no significant effect on certain species. For example, Durnin et al. (2004) conducted a study in which four captive giant pandas (*Ailuropoda melanoleuca*) (two male and two female) were anesthetized and fixed with radio collars. The goal of the study was to determine whether or not the collars negatively impacted the hormones and stress-related behaviors of the pandas (Durnin et al. 2004). The authors compared the behaviors and hormone levels two weeks prior and after the animals were fitted with collars and found no significant changes in either area (Durnin et al. 2004). Likewise, Golabek et al. (2008) claimed that meerkats (*Suricata suricatta*) are not negatively impacted by radio collars. They found that meerkats were not predated upon more than their non-collared counterparts, and that their foraging ability was not significantly altered during or after collaring (Golabek et al. 2008).

In the last comprehensive review of the literature regarding the effects of radiotelemetry on wildlife, Withey et al (2001) assert that studies in which radiotelemetry is employed make the assumption that animals fitted with any sort of tracking device are "moving through the environment, responding to stimuli, and behaving in a manner similar to non-instrumented animals" (Withey et al. 2001:44). They maintain that in spite of this assumption "fewer than 100 published studies in leading journals address the effects of radio-tagging on study animals" (Withey et al. 2001:44). This is most likely because the majority of species studied using telemetry technologies are incredibly difficult to study, so that studies comparing the behavior of collared or tagged animals to those without tracking devices become particularly difficult (Withey et al. 2001). Tuyttens et al. (2002:37) also explain that an intrinsic postulation in these types of studies is that the "radio-tagged animals are representative of the entire study population" but maintain that studying possible behavioral "effects of attaching a radio-tag are difficult to quantify in wild animals."

Implementation of Tracking Technology in Primatology: Concerns for Primate Health and Behavior

During recent decades the use of telemetry in primatological field studies, to track and record data on the behavior of many different primate species has increased, but as Campbell and Sussman (1994) assert it has not been without reservations. They emphasize that the use of radio-tracking can provide a number of benefits to wildlife studies, particularly when studying wild primates that are nocturnal, live in fission-fusion groups, or inhabit difficult terrain that has dense vegetation (Kalpers et al. 1989; Campbell and Sussman 1994). As with non-primate animals, it is not well known whether or not collars, used for radio-tracking or GPS technology, negatively impact the health or behavior of the individual primates being studied. Studies have shown that, similarly to other animal species, primates can incur extensive and sometimes fatal injuries from too heavy or ill fitting collars (Juarez et al. 2011). In order to be fitted with radio collars, animals have to be anesthetized, and this can be a costly endeavor that could potentially harm, or even kill the animal (Campbell and Sussman 1994).

Moreover, concern has been raised in regards to the effects that the presence of the collars may have on behavior. Although widely used in the study of nocturnal prosimians, the assumption that radio collars do not significantly alter the behavior of the animal being studied and thus the data gathered is largely untested (Gursky 1998). This is especially true for black-handed spider monkeys (*Ateles geoffroyi*), the species focused on for this study. To date there have been no studies conducted on the behavioral effects of collars in this species of spider monkey. Like many all primate species, spider monkeys inhabit difficult terrain. They also prefer the higher strata of the forest and can move quickly throughout the forest in small foraging parties. All of these characteristics make the black-handed spider monkey (*Ateles geoffroyi*) an ideal candidate for remote tracking and studies investigating possible effects of the collars used for remote tracking.

This study brings to light important ethical considerations for field primatologists. In recent years primatologists have been reevaluating ethical issues faced by field primatologists. One of the primary concerns that primatologists must consider when conducting field research is the health and welfare of the research species (MacKinnon and Riley 2010). Usually much attention is paid to the treatment and welfare of animals researched in captivity. Recently more and more accounts of ethical issues faced in the field have surfaced (Fedigan 2010:757; MacKinnon and Riley 2010). The approval for non-human primate research is usually sought through animal care committees initially designed for biomedical research which emphasize the "Three R's" (replacement, reduction, and refinement) (Fedigan 2010; MacKinnon and Riley 2010:750). These principles typically lack significance for field research (MacKinnon and Riley 2010). By conducting a survey Fedigan (2010) was able to glean some more realistic considerations that animal care forms for field primatologists should address. One of those questions on the survey asks researchers to describe what possible negative impacts their research could have on the “behavior, survival and reproduction” of the animals they study(Fedigan 2010:768). The survey also explores how the environment and the local human community could be impacted, and what steps the researcher will take to diminish these effects (Fedigan 2010). This is just one of many questions that Fedigan (2010) proposes on her example of an animal care form for field research. Malone et al. (2010) caution field researchers against the common justifications of conservation and development of local economies for primatological field studies. They ask that researchers step back and carefully consider whether the research is truly needed. These are all important complications for primatological field research and important to the future development of an official ethics code for researchers. This study highlights Fedigan’s (2010) concern that the costs and benefits of one’s methodologies may negatively impact a study species and needs to be considered in great detail before stepping foot into the field.

Study Species: Genus *Ateles*

There are many different species within the genus *Ateles* (spider monkeys) which range throughout Central and South America. They have one of the largest geographical distributions of any primate in the Neotropics (Collins 2008). Spider monkeys are highly frugivorous, so much so that they are classified as “ripe fruit specialists” (Di Fiore et al. 2008; Takahasi 2008), with fruit constituting upwards of 85-90 percent of their diet (Di Fiore et al. 2008; Takahasi 2008; Gonzalez-Zamora et al. 2009). Furthermore, the dietary preference of spider monkeys influences their social structure. The latter is characterized by high levels of fission-fusion, meaning spider monkey groups often split into smaller foraging subgroups during the day and in the evening reunite in their sleeping trees however this does not always occur every night (Aureli and Schaffner 2008; Di Fiore et al. 2011). This heavy dependence on a patchily distributed and highly nutritious food source means that spider monkeys generally must travel great distances foraging for food (Gonzalez-Zamora 2009). Spider monkey home ranges are quite large when compared to other monkeys that reside in the same environment (Takahasi 2008). Researchers have found that home range size can vary between males and females, with female spider monkeys having smaller home ranges than males (Fedigan 1988; Takahasi 2008). Female home ranges can also be impacted by the weight of a dependent infant (Fedigan 1988; Takahasi 2008). Average home range size for spider monkeys in Santa Rosa, Costa Rica was 62.4 ha. Male and female spider monkeys in Yasuní National Park, Costa Rica had home range sizes of 350 ha and 80 ha respectively (Takahasi 2008). The spider monkey group I observed inhabits a protected island reserve in Panamá called Barro Colorado Island (BCI). It is believed that the single group of spider monkeys on BCI range nearly the entire island which is roughly 1500 ha (Leigh et al. 1982), with estimations as high as approximately 960 ha (Campbell 2000a), making radio tracking all the more vital in studies concerning this particular group. This particular group of black-handed spider monkeys (*Ateles geoffroyi*) has been heavily researched, with studies dating as far back as the early 1960s (see Table 1 for detailed information regarding past studies done on the black-handed spider monkeys (*Ateles geoffroyi*) on BCI).

Table 1. Past studies conducted on the black-handed spider monkeys (*A. geoffroyi*) on Barro Colorado Island (BCI), Panamá

Researcher	Time of Study	Primary Research Objectives	References
John F. Eisenberg and Robert E. Kuehn	1963-65	General behavior	1966
Allison Richard	1968	Activity patterns	1970
Ronald J. Dare	1972	Social behavior and ecology	1974
Jorge A. Ahumada	1988-89	Grooming behavior	1992
Katherine Milton	1975-81	Reproduction, diet, and	1981a, 1981b, and 1993
Christina J. Campbell	1997-2004	Reproduction, fur rubbing behavior, female-directed aggression, terrestrial behavior, male coalitionary aggression towards subadult males.	2000a,2000b,2001, 2003, 2004, et al. 2005, 2006a, and 2006b
Stephanie Ramirez	2010-2011	Reproductive ecology	No publications to date

The Importance of Grooming in Primate Social Systems

Two primary hypotheses have been put forward concerning the function of allo-grooming in primate societies, one being hygienic and the other social (Grueter et al. 2013). Even though grooming is known to have initially evolved for hygienic purposes (Grueter et al. 2013) and plays an important role in disease control (Freeland 1976) it is now widely accepted that grooming plays an integral role in the continuance of social bonding and cohesiveness of primate groups (Seyfarth 1983; Dunbar 1991; Pastor-Nieto 2001; Grueter et al. 2013). Grooming is one of the more common affinitive primate behaviors observed (Cheney and Seyfarth 1990), so much so that some species have been observed grooming upwards of 20 percent of their day (Lehmann et al. 2007). This behavior can serve as a way to relieve stress or tension (Terry 1970), reinforce group hierarchies, reinforce social bonds between individuals, and can aid in the formation of alliances between individuals. Frans De Waal's (1997) work presents critical substantiation for the social significance of grooming in his study regarding chimpanzees (*Pan troglodytes*) using grooming as a way to gain access to food. Schino and colleagues (1988) tested the hypothesis that allogrooming aids as a way to reduce tension in crab-eating macaques (*Macaca fascicularis*). In testing the tension-reduction hypothesis the authors found that allogrooming was effective in reducing tension during the duration of grooming. In addition the authors found that in other instances displacement behaviors were reduced as a result of being groomed (Schino et al. 1988).

Andelman (1986) suggested that one aspect of social grooming is the formation of consortships. In those primates that are known to form mating consortships grooming plays a critical role in maintaining those bonds (Andelman 1986). The author discusses the point that in some species that maintain uni-male or multimale groups and lack the formation of consortships, male grooming of females is relatively absent, and that the principal purpose of "sexual grooming" is to sustain "spatial proximity of consort partners" (Andelman 1986:215). Manson (1997), adding additional support to this idea, maintains that when determining what constitutes a consortship within a primate social group grooming is almost always one of the essential characteristics.

According to Silk (1987), grooming patterns in juvenile baboons (*Papio*), bonnet macaques (*Macaca radiata*), rhesus macaques (*Macaca mulatta*), Japanese macaques (*Macaca fuscata*), and vervets (*Chlorocebus pygerythrus*) strongly indicate that females start to carry out adult grooming behaviors early and show a preference for grooming other females more than other group members when compared to males. Silk also maintains that when an immature female grooms an individual that is not closely related to her, the groomed individual is most likely to be of a higher rank (Silk 1987). This observation provides integral evidence in support of the understanding that grooming may be used as a tool for alliance formation, because directing the grooming up the hierarchy may aid in forming a bond with that individual that may be useful at a later time (Silk 1987).

In addition to the important social function, grooming also plays an integral role in the removal of ectoparasites in many primate species. It has been observed that many focus their grooming to certain parts of the body that are usually unreachable to the individual being groomed (Hutchins and Barash 1976:145). In their paper, Hutchins and Barash present what they believe is the "first quantitative data" in support of a utilitarian function of grooming based on observations of three captive species of primates: the ring-tailed lemur (*Lemur catta*), lion-tailed macaque (*Macaca silenus*), and Celebus black "ape" (*Macaca niger*) (Hutchins and Barash 1976:145). They report that despite its social function, grooming is an extremely adapted behavior that serves a "utilitarian skin-care function" (Hutchins and Barash 1976:146). Moreover, McKenna (1978) highlighted the role that grooming plays in disease control.

Although an ample amount of research has been conducted concerning the role of grooming in Old World primate social groups, grooming in New World monkeys has not been investigated as thoroughly (Pastor-Nieto 2001). Studies such as those by Fedigan (1993) on white-faced capuchins (*Cebus capucinus*) and O'Brien (1993) on wedge-capped capuchins (*Cebus olivaceus*) indicate that grooming serves an important social function in these neotropical monkeys, and that although it may possibly be a less frequently observed behavior it is still essential (Pastor-Nieto 2001). One of the issues that arises when studying affiliative behaviors among the genus *Ateles* is that their characteristic social system (fission-fusion) means that they spend a great deal of their day split up into small foraging parties that change structure often. This aspect of their social system makes them less cohesive, but even so it is still necessary to maintain a certain level of interconnectedness (Pastor-Nieto 2001). As well as there being a lack of studies on grooming for New World monkeys the studies also tend to be focused on "monogamous genera such as *Callicebus* and *Aotus*" (Ahumada 1992:34). Comprehensive studies on the grooming behavior in wild ateline populations are scarce, but there are some data from studies conducted on captive ateline primates (Pastor-Nieto 2001) and "some information on grooming bout duration and partner preferences for free-ranging spider monkeys" (*Ateles*) (Ahumada 1992:34). Ahumada (1992:44) concluded that although the results of his study indicated that grooming among the group of spider monkeys on BCI is "a short, infrequent behavior performed mainly during long resting bouts" it is still the "most frequent affinitive behavior that spider monkeys show."

All of the points mentioned above indicate the importance of grooming to primate social systems. Again, although it is often an infrequent behavior among the black-handed spider monkeys (*Ateles goeffroyi*) on BCI it is one of the more important ways that they maintain group cohesion. All of the aforementioned information is the main reason that this behavior was chosen as the focus of the study presented in this thesis. When attempting to understand the possible behavioral effects of collaring, grooming is potentially the most important behavior that could be impacted. If the collars are impacting the grooming behavior of those females the potential costs to their overall health and social standing within the group could be in jeopardy.

Specific Study Goals

Beginning in January 2010 Dr. Christina Campbell, of California State University Northridge, and her colleagues darted and collared nine adult female spider monkeys. Of the nine individuals eight were fitted with radio collars and the other with a GPS collar. Two of the eight radio-collared females have died from reasons that appear to be associated with old age and poor body condition during a time of food scarcity when a number of noncollared spider monkeys also died (Campbell, unpublished data). An additional female was darted in January 2012 in order to remove the collar and assess her health. There are now six individuals with collars remaining (five radio collars and one GPS collar).

This study sought to gain insight into the aforementioned issue by comparing the grooming behavior of collared and non-collared female black-handed spider monkeys (*Ateles geoffroyi*). The goal of this study was to understand whether or not radio or GPS collars are having an adverse behavioral effect on these animals. Spider monkeys, known for being somewhat elusive animals, makes them perfect candidates for the use of radio tracking and or GPS collars and also perfect candidates to attempt to investigate any possible effects those collars may have on their behavior. In this study, I aim to shed light on whether there are significant differences in rates of grooming between collared and non-collared females, i.e., do collared females groom themselves (auto-grooming) more or less than non-collared females, or do collared females give grooming to or receive grooming from another individual (allogrooming) more or less than non-collared females. An increased rate of auto-grooming, particularly around the area of the collar, could indicate that the collars are irritating the individual. A lower rate of allogrooming (an affiliative behavior that strengthens social bonds) both given and received by collared females could suggest a level of social isolation, because as mentioned previously grooming is an extremely important behavior in which primates maintain group cohesion. No difference in grooming between collared and non-collared individuals would strongly suggest that the collars do not have an impact on the animal's social standing in the group or their overall physical health. And more importantly, this study provides an opportunity to compare the behavior of collared and non-collared individuals from the same group inhabiting the same environment, which has not always been possible in earlier studies (Golabek et al. 2008). This study will provide preliminary answers to the question of how collars may or may not affect behavior, and is a vital step in understanding just how collars influence study subjects.

METHODS

Study Site

Barro Colorado Island (BCI), Panamá, was formed in 1914, when the Chagres River was dammed in order to form Lake Gatun. The flooding in nearby mainland areas created several islands, the largest of which is BCI (Leigh et al. 1996) (see Figure 1). The island is approximately 1500 ha of dense lowland tropical rainforest with an average annual rainfall of 2600 mm (Dietrich et al. 1996; Leigh et al. 1996). Most of the island is secondary old growth forest, while some areas are older primary forest (Foster and Brokaw 1996). The island is part of the Barro Colorado Nature Monument (BCNM) in Panamá which includes other mainland areas such as the Gigante, Peña Blanca, Bohio, Buena Vista, and Frijoles peninsulas and has been a protected reserve since 1923 (Leigh et al. 1996). As of 1946 the Smithsonian Tropical Research Institute (STRI) protects the island and oversees the research conducted there and in the surrounding areas (Leigh et al. 1996).

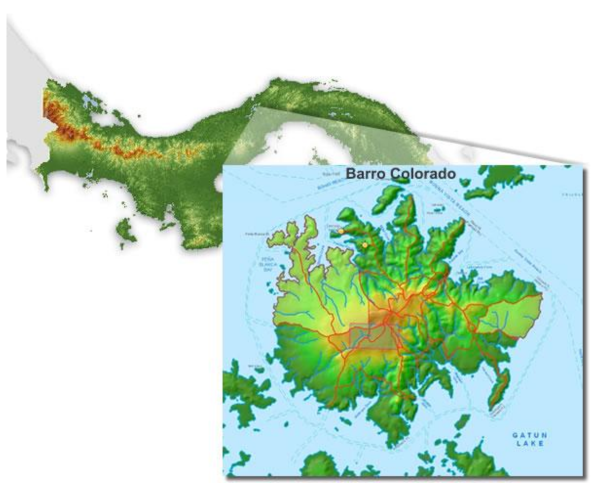

Fig 2.1. Map depicting BCI in relation to Panamá. The map gives a detailed view of the island (http://biogeodb.stri.si.edu/biodiversity/bci/ ,credit: Smithsonian Tropical Research Institute)

Study Group

This study was conducted on the single group of black-handed spider monkeys (*Ateles geoffroyi*) on BCI. The most recent census of the spider monkeys on BCI recorded approximately 42 individuals (Campbell unpublished data 2013; see Table 2 for breakdown of group composition). At the time the island was separated from the mainland three populations of primate species were stranded on the island, *Alouatta palliata* (mantled howler monkey), *Cebus capucinus* (white-faced capuchin), and *Saguinnus geoffroyi* (Geoffroy's tamarin) (Milton and Hopkins 2006). At the time that BCI was formed, spider monkeys had been extirpated from the areas surrounding the canal due to hunting and degredation of their habitat (Campbell 2000a). A small group of juvenile black-handed spider monkeys (*Ateles geoffroyi*) were released onto the island in the late 1950s and the early to late 1960s (Campbell 2000a) (see Table 1 for detailed information regarding past studies done on the black-handed spider monkeys (*Ateles geoffroyi*) on BCI). A second introduction in the early 90s has been confirmed through an investigation of the mtDNA of the group (Campbell, unpublished data).

Table 2. Breakdown of Group Composition (Campbell unpublished data 2013).

Adult Female	Adult Males	Sub Adult Females	Sub Adult Males	Juvenile Females	Juvenile Males	Infant Females	Infant Males	Infants of Unknown Sex	Total
13	3-4	3-4	4	3	6	2	0	6	40-42

The focal individuals included six collared females, 5 with radio collars and 1 with a GPS collar (for detailed information regarding the collared females see Table 3).

The remaining 7 adult non-collared females were the focal individuals to which the grooming behavior of the collared females was compared.

Table 3. Detailed information for each collared female at time of collaring in 2010.

Animal Name	Age at Time of Collaring	Date Collared	Collar Type	Associated Offspring
JL	Adult	8/8/2010	Radio	Juvenile Male
VA	Sub Adult	8/10/2010	Radio	None
LA	Young Adult	8/10/2010	Radio	None
MC	Older Adult	8/13/2010	Radio	Juvenile Male
SR	Young Adult	8/13/2010	Radio	None
BA	Sub Adult	1/9/2010	GPS	None

Data Collection

Over a period of six months (May-Nov2012) and then again opportunistically during a three month period (June-Aug 2013), research was conducted on BCI to assess whether or not collars were affecting the grooming behavior of female spider monkeys (*Ateles geoffroyi*). During the research periods, data on the general activity budgets of the various sub-groups of spider monkeys were collected in conjunction with grooming data. During those times that I did not have the aid of field assistants data collection began at 6am or when first contact with the group was made, and continued throughout the day until 6pm or as long as contact with the group was maintained. With the support of field assistants it was possible to implement a data collection schedule where either myself or a field assistant would conduct full or half day follows (i.e., 6am-6pm, 6am-12pm, 12pm-6pm). With or without field assistants the group was followed for the entire day or for as long as contact could be maintained. With the assistance of radiotelemetry equipment I was able to locate certain sub-groups that contained one or more radio collared females. It is important to note that the telemetry equipment was not always functional throughout the study periods which made locating collared females even more opportunistic.

Using methods of focal-animal sampling and scan/instantaneous sampling (Altman 1974) data were collected on focal animals (i.e. collared and non-collared females) and also the entire subgroup of spider monkeys being followed. Scan/instantaneous sampling was used to record an individual's, or in the case of this study a subgroup's, present activity at predetermined times and is used to ascertain the percentage of time spent exhibiting certain behaviors (Altman 1974) thus allowing an observer to produce an activity budget. Every 5 minutes a scan sample of the entire subgroup was conducted and their behaviors were noted. There were 4 major behavioral categories: feed/forage (F), rest (R), travel (T), or other (OT). Behaviors that were included in the category of other were play, groom, agonistic encounter, alarm calling, and copulation (See Table 4 for full definition of terms). Moreover, this is a method used to "sample states, not events" (Altman 1974:258). For this study I was interested in obtaining information on the state of the subgroup being followed which meant scanning all the visible individuals at the same time. After completing the scan all observed behaviors were recorded in the aforementioned categories. More often than not certain individuals within the subgroup would be visible and others would be too high in the canopy to adequately observe. If some individuals were in sight while others were not the behaviors of the indivuals that could be seen were noted and taken to be representative of all group members. If individuals were exhibiting different behaviors (i.e., one resting and one feeding/foraging) then both behaviors were recorded.

Table 4. Activity budget behavior abbreviations and definitions used during study.

Abbreviation	Definition	Description
F	Feed/Forage	Actively feeding (placing food into the mouth) or in search of food (foraging) within a feeding site.
R	Rest	Sitting or lying down motionless for an extended amount of time.
T	Travel	Moving from one feeding site to another or moving from feeding to sleeping site.
OT	Other	The category of other includes the following behaviors:

Abbreviation	Definition	Description
GR	Grooming	Actively searching through the fur of another individual or themselves and/or removing ectoparasites.
PLY	Play	
AE	Agonistic Encounter	Agonistic Encounter within group or with other primate species= behaving aggressively toward another individual within the group or towards another animal species
COP	Copulation	Actively engaging in copulatory behavior between a male and a female spider monkey.
AC	Alarm Call	Actively engaging in the specific vocalization, which is a loud screech call, which is meant to alert group members to a possible threat.

Focal-animal sampling is a method in which occurrences of a specified behavior are recorded for a predetermined set of time (Altman 1974). Upon locating either a collared or non-collared female I began a thirty-minute focal follow. This method of focal animal sampling is one of the more standard techniques used in studies regarding primate social behavior (Campbell et al. 2011). If the focal animal was observed grooming during the focal follow, the start and end times of the grooming bout were recorded. I also made note of the age and sex class of the grooming partner and of role-switching (i.e., going from receiver to giver and vice versa) and the location on the body that was being groomed (i.e., neck or general body. These two areas were chosen in order to test for any significant differences in rates of grooming (either allogrooming or auto-grooming) on different areas of the body. Since allogrooming or auto-grooming around the neck area could indicate collar iritation this area was focused on and all other areas of the body were consolidated into the category of general body. A grooming bout was defined as a period of time where the focal animal was engaged in grooming an individual, being groomed by another indvidual, or grooming themselves. If grooming ceased for more than 10 seconds, this marked the end of that particular grooming bout. If the direction of grooming switched from focal to partner or vice versa, new start and end times were recorded and marked a separate grooming bout (see Tables 5 and 6 for detailed information regarding the data collection for grooming bouts). The age and sex class was determined by using Campbell's (2000a) protocol (see Table 7 for detailed age and sex class information). The behavior of the six collared females was then compared to behavioral observations of all other non-collared females within the group.

Table 5. Categories and data collected for grooming data.

<table>
<tr><th>Abbreviation</th><th>Definition</th><th>Description</th></tr>
<tr><td>F</td><td>Focal Animal</td><td>Description of the focal animal being followed for the focal period. Can only be UF or CF.
<table>
<tr><th>Abbreviation</th><th>Definition</th><th>Description</th></tr>
<tr><td>UF</td><td>Non-collared Female</td><td>UF is defined as any female not fitted with a radio or GPS collar.</td></tr>
<tr><td>CF</td><td>Collared Female</td><td>CF is defined as any of the radio collared females or the one female with the GPS collar.</td></tr>
</table></td></tr>
<tr><td>P</td><td>Partner</td><td>See Table 8</td></tr>
<tr><td>Dir</td><td>Direction</td><td>Allogrooming:
F→P=focal animal grooming the partner or
P→F=partner grooming the focal animal.
Auto-grooming:
F→F=focal animal grooming themselves (auto-grooming)</td></tr>
<tr><td>T/S</td><td>Start Time</td><td>Start time of the grooming bout (if grooming was observed during the focal follow) is noted as well as the start time for the focal follow.</td></tr>
<tr><td>←→?</td><td>Change in Direction?</td><td>It was noted if the direction of the grooming changed
For example: Grooming initially started as F→P and then changed to P→F. After a change in direction is noted new start and end times were recorded as this denoted and separate grooming bout.</td></tr>
<tr><td>Loc</td><td>Location on Body</td><td>Two categories were used for location on the body being groomed:
GB or General Body
NK or Neck</td></tr>
<tr><td>T/E</td><td>End Time</td><td>End time of the grooming bout is noted as well as the end time for the focal follow.</td></tr>
</table>

Table 6. Two examples describing how grooming data was collected during focal follows.

Example of data recorded if grooming was observed during focal follow.						
F	P	Dir	T/S	←→?	Loc	T/E
CF or NF	Focal individual or any other individual within the group	F→P,P→F, or F→F	Start of grooming bout	Note the direction of grooming and if it changes	NK/GB	End of grooming bout
Record any relevant notes here.						
Example of data recorded if no grooming was observed during focal follow.						
F	P	Dir	T/S	←→?	Loc	T/E
CF or NF	--					
If no grooming is observed during the focal follow a line is drawn through and only the focal category is filled in, and relevant notes recorded.						

Table 7. Campbell (2000a) age/sex class protocol.

Age/Sex Class	Description
Adults	Approximately 5.5 + years of age. Fully grown. Females have offspring. Darker pigmentation of face (becomes increasingly darker with age.)
Subadults	Approximately 4.5-5.5 years of age. Approximately 75-80 % of full adult body size. Females do not have offspring, males usually associate entirely with other adult males.
Juvenile 2	2.5 years to about 4.5 years old. Never carried by mother but still associates with her at all times. Often rests apart from mother. Males begin to associate with adult males more.
Juvenile 1	1 year to about 2.5 years old. Lightening of pelage from infant stage. Occasionally travels independently, but still mostly carried by mother dorsally. Usually engaged in play (more often with other group members) away from mother when she is resting.

Infant 2	6 months to 1 year. Some lightening in the color of dorsal hair. Riding mother dorsally. Occasionally ventures from mother to play (usually solitary play).
Infant 1	0-6 months old, very dark pelage (when compared to the red color of the adults). Rarely, if ever ventures from mother. Rides mother ventrally when traveling.

A portion of the study that changed was the comparison of the behavior of collared females while collared with their behavior after the collars dropped off. The particular type of radio collars worn by the female spider monkeys had a computerized drop off mechanism, and they were scheduled to drop off on August 12, 2013. Unfortunately, the drop off mechanisms in the collars failed. Subsequently, the study became a comparison of the behavior of non-collared females and collared females only.

Data Analyses

Using Excel 2007, I conducted chi-squared tests for association using 2x2 contingency tables with 1 degree of freedom and a Yates correction to calculate expected values in order to determine the χ^2 value to ascertain whether any of the differences in the frequencies of these behaviors were statistically significant. The first test looked at the overall frequency of grooming. For this test I compared focal follows with and without grooming for non-collared and collared females. Next, I looked at the frequencies of type of grooming. The frequencies of the binary categories, auto-grooming and allogrooming, were compared between both groups. Then, within the instances of auto-grooming I compared frequencies of grooming around the neck or the general body between the two groups. In addition to these tests I also compared the frequencies of initiating and receiving allogrooming between non-collared and collared females. And finally, I compared frequencies of non-collared and collared females with and without offspring.

In addition to the chi-squared tests I also compared rates of grooming around the neck and general body throughout all types of grooming. Grooming the neck and general body can occur during any single grooming bout. This made the use of a chi-squared analysis inappropriate. For these data I calculated the standard error with 95 percent confidence intervals. I also conducted a Mann-Whitney *U* test for unmatched samples on the grooming bout duration of auto-grooming and the duration of grooming for all grooming bouts between non-collared and collared females.

RESULTS

Grooming Data

My field assistants and I collected a total of 72 focal follows during the study periods. Of those 39 were conducted on non-collared females and 33 on collared females. Out of the 72 focal follows there were 22 where grooming bouts occurred; sometimes multiple grooming bouts occurred during one focal follow. There were 45 grooming bouts total, of which 21 were grooming bouts for non-collared females and 24 for collared (see Table 8). I conducted chi-squared analyses using 2x2 contingency tables with 1 degree of freedom and a Yates correction to calculate expected values in order to determine the χ^2 value to ascertain whether any of the differences in the frequencies of these behaviors were statistically significant (see Table 9 for detailed information regarding χ^2 tests conducted and results). The first test was done on the frequency of grooming bouts between collared and non-collared females, and the result was not statistically significant ($\chi^2 = 2.795$, DF = 1, $p > 0.05$). In other words, when the numbers of focal follows with grooming and those without were compared between the two groups I did not find that non-collared females are engaged in grooming more frequently than collared females. The same can be said when comparing the frequency of allogrooming and auto-grooming ($\chi^2 = 0.494$, DF = 1, $p > 0.05$) (see Figure 3.1). Therefore, there is not a statistically significant association between the presence or absence of collars and the type of grooming, but when focusing on just collared females there does appear to be a higher occurrence of allogrooming among collared females compared to auto-grooming frequencies (see Figure 3.1). In addition, there is no significant association between the area of the body (i.e., neck or general body) being groomed during auto-grooming and the presence or absence of collars (χ^2 = 1.156, DF = 1, p > 0.05) (see Figure 3.2). Furthermore, there was no significant difference in initiating and receiving allogrooming between non-collared and collared females (χ^2 = 0.847, DF = 1, p > 0.05), (see Figure 3.3).

Table 8. Breakdown of focal follows.

# of Focal Follows	# of Focal Follows with Grooming Bouts	Total # of Grooming Bouts	# of Focal Follows for Non-Collared Females	# of Focal Follows for Collared Females	# of Grooming Bouts for Non-Collared Females	# of Grooming Bouts for Collared Females
72	22	45	39/72	33/72	21/45	24/45

Table 9. Details of χ^2 tests.

Comparison	Category	*N* Collared Females	*N* Non-Collared Females	χ^2	p
Focal Follows	With grooming	24	21	2.795	> 0.05
	Without grooming	9	18		
Type of grooming	Auto-grooming	7	8	0.494	> 0.05
	Allogrooming	17	13		
Area of body during auto-grooming	Neck	2	0	1.156	> 0.05
	General Body	5	8		
Allogrooming	Initiate	14	9	0.847	> 0.05
	Receive	3	4		
Females and offspring	With	5	7	2.201	> 0.05
	Without	1	0		

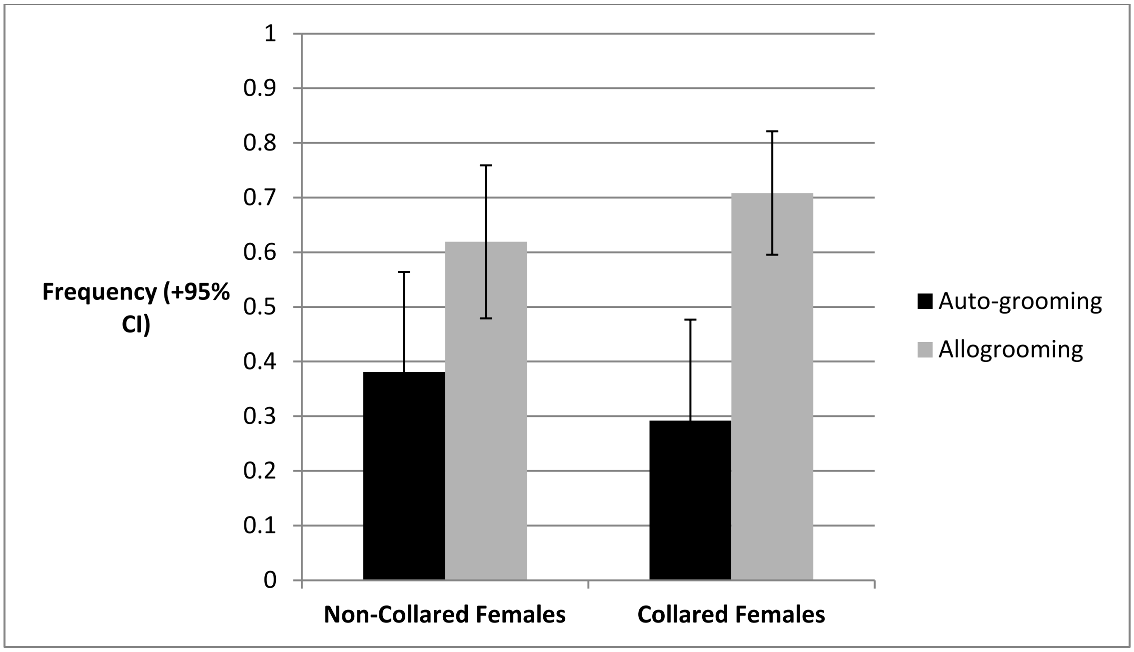

Fig 3.1**.** Relationship between non-collared and collared females in the frequency of auto-grooming and allogrooming taken as the proportion of auto-grooming and allogrooming out of the total number of grooming bouts for each group with 95 % CI (confidence interval) (see Table 9 for χ^2 results).

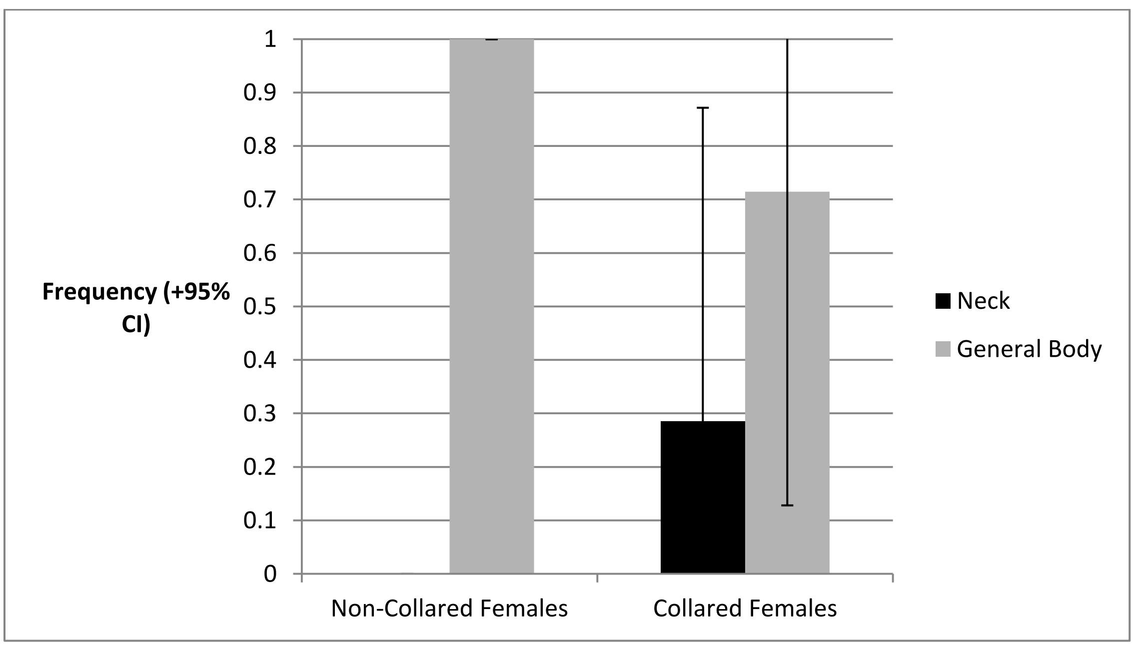

Fig 3.2. Relationship between non-collared and collared females in frequency of auto-grooming of the neck or general body taken as the proportion of grooming around the neck and general body out of the total number of auto-grooming bouts with 95 % CI (confidence interval) (see Table 9 for χ^2 results).

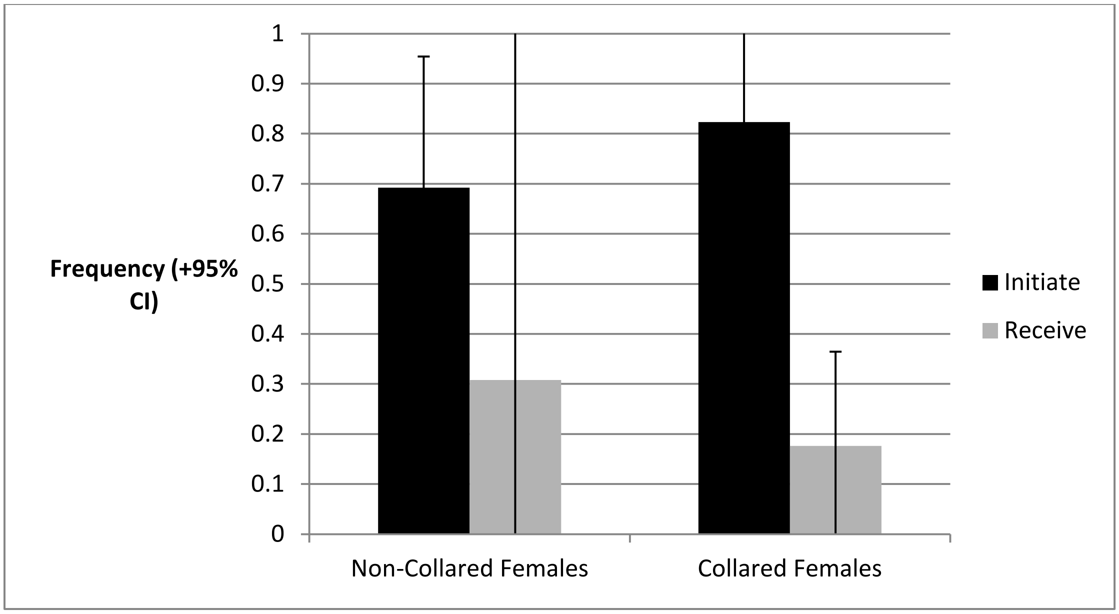

Fig 3.3. Relationship between non-collared and collared females in the frequency of initiating and receiving allogrooming taken as the proportion of initiating and receiving out of the total number of allogrooming bouts in each group with 95 % CI (confidence interval (see Table 9 for χ^2 results).

I also looked at possible differences regarding the region of the body groomed for all grooming bouts between non-collared and collared females (see Figure 3.4). A chi-squared test for statistical significance was not conducted on these data due to the fact that within any one grooming bout both areas (neck and general body) could have been groomed. It is these double counts that make the chi-squared test unsuitable in this instance, but 95 percent confidence intervals were calculated which give an indication that there is no statistical difference between the presence or absence of collars and the area of the body being groomed. Figure 5 shows that both non-collared and collared females exhibit less grooming around the neck than the general body. Although grooming around the neck is more frequent in collared females than in non-collared females, both show the same pattern of grooming around the neck and general body.

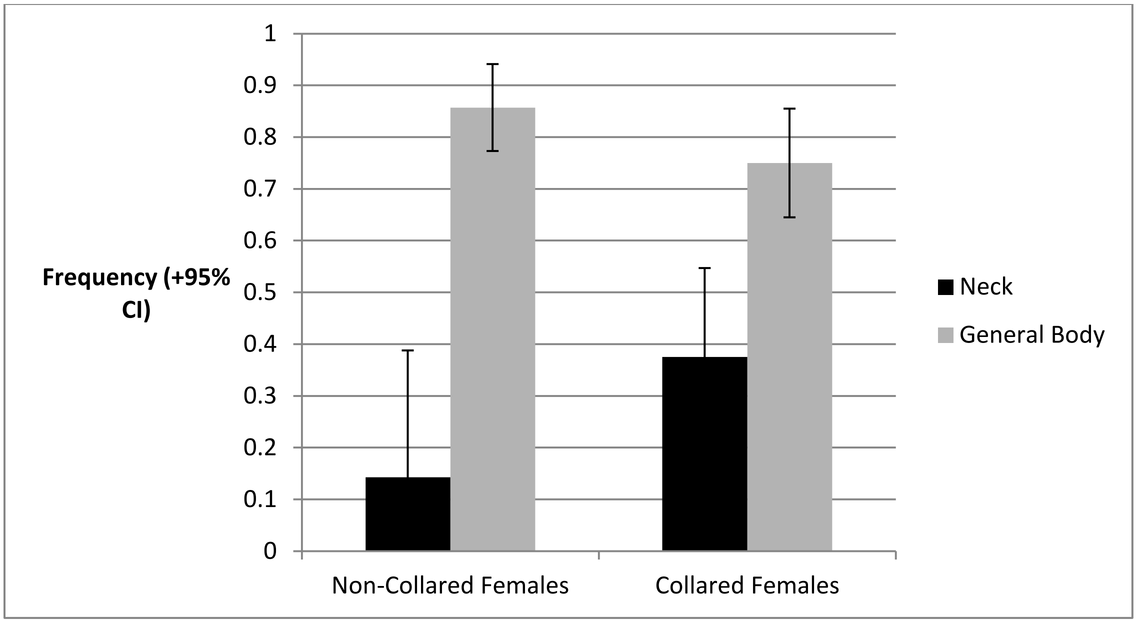

Fig 3.4. Relationship of grooming on the neck and general body between non-collared and collared females taken as the proportion of grooming on the neck and general body out of the overall total number of grooming bouts for both groups with 95 % CI (confidence interval) (see Table 9 for χ^2 results).

In addition to the aforementioned tests, I also constructed box plots in order to graphically represent any differences there may be in the duration of grooming bouts within some of the previous categories. The series of graphs below show that the median grooming bout durations (in seconds) do not differ between collared and non-collared females (see Figures 3.5, 3.6, and 3.7). The results of the Mann-Whitney *U* test indicate that there is no statistically significant difference in the duration of auto-grooming between the two groups ($U = 26$, $p > 0.05$). Moreover, there is no statistically significant difference between the two groups when analyzing the duration of combined grooming bouts ($U = 232.5$, $p > 0.05$).

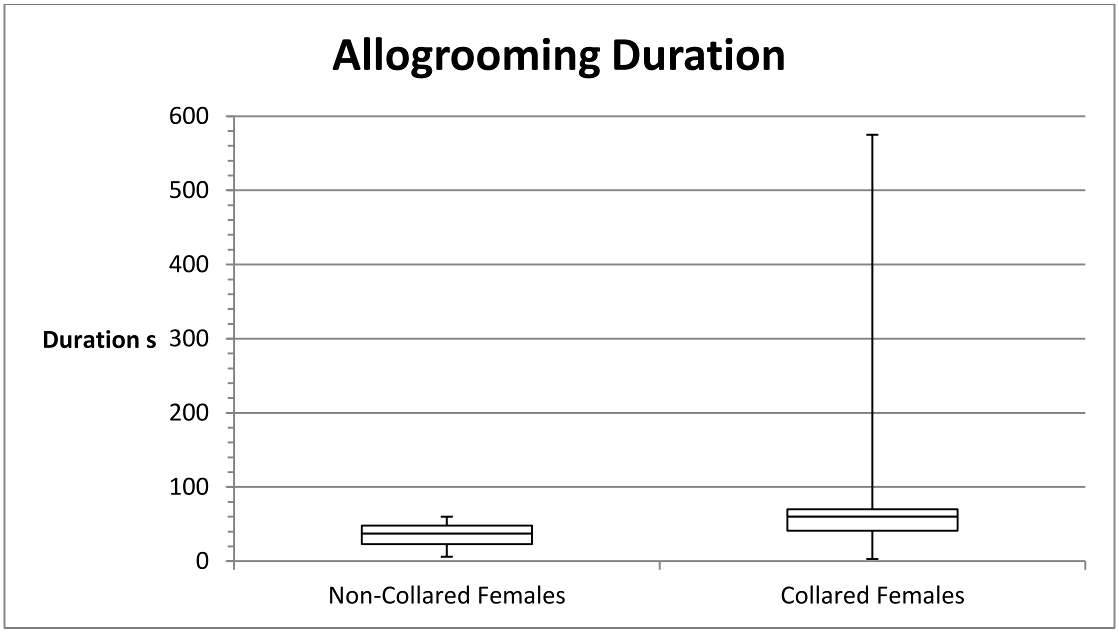

Fig 3.5. Box plot indicating the median grooming bout duration (in seconds) in non-collared and collared females. Upper and lower boxes represent the 25th and 75th percentiles respectively.

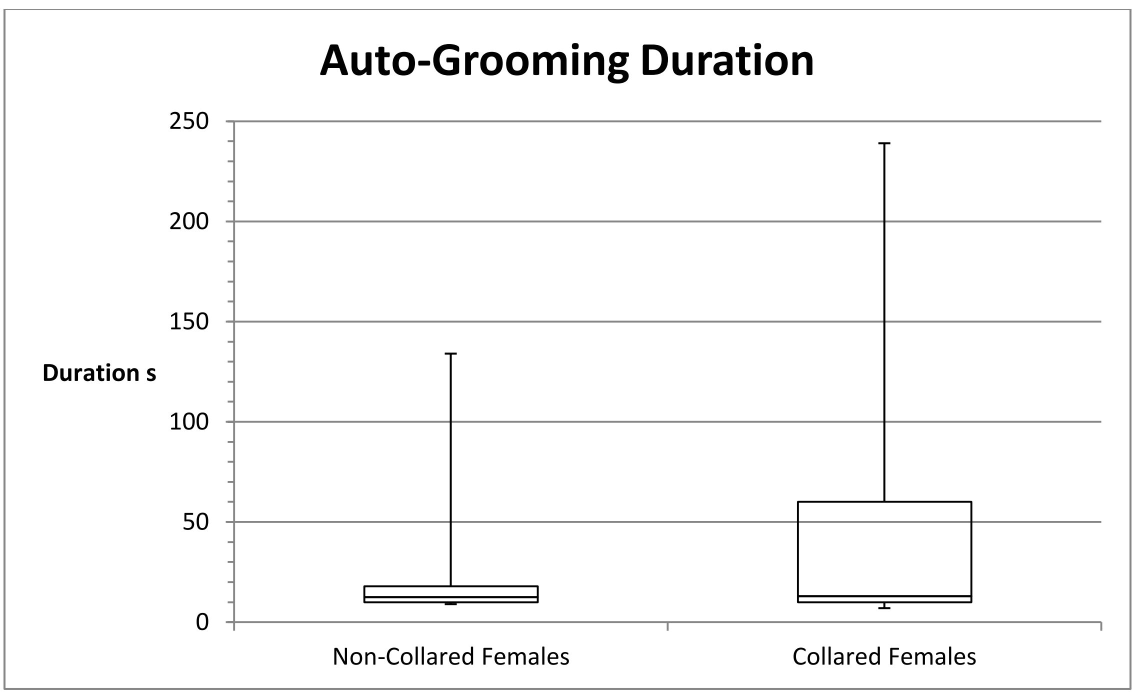

Fig 3.6. Box plot indicating the median grooming bout duration duration (in seconds) in non-collared and collared females. Upper and lower boxes represent the 25th and 75th percentiles respectively.

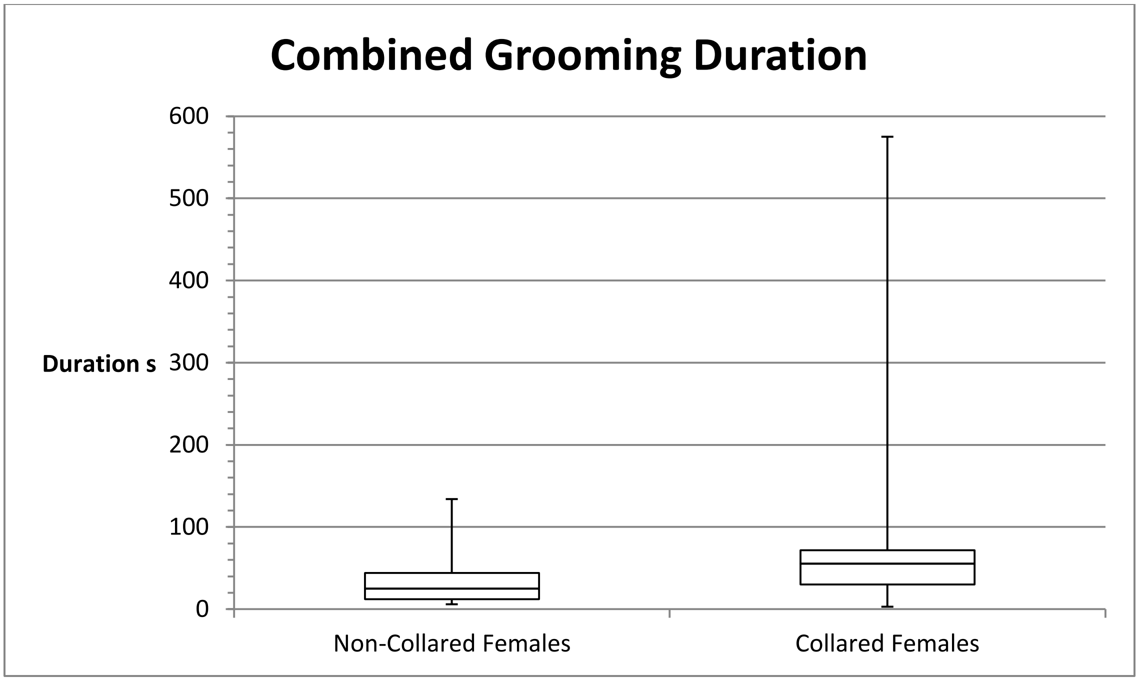

Fig 3.7. Box plot indicating the median grooming bout duration (in seconds) in non-collared and collared females. Upper and lower boxes represent the 25th and 75th percentiles respectively.

Activity Budget Data

The result of the activity budget data (see Figure 3.8) that were collected during the study period indicate that the spider monkeys (*Ateles geoffroyi*) on BCI spend very little of their time grooming. Overall it accounts for 1.8 percent of the total observation hours of their activities. Feeding and foraging accounted for the majority of their daily activities which totaled 41 percent the second most frequent behavior was resting at 34 percent, with traveling at 12.6 percent, playing at 8 percent, agonistic encounters at 1.2 percent, alarm calling at 1.2 percent, and copulation at .04 percent (only one observed instance of copulation involving a collared female).

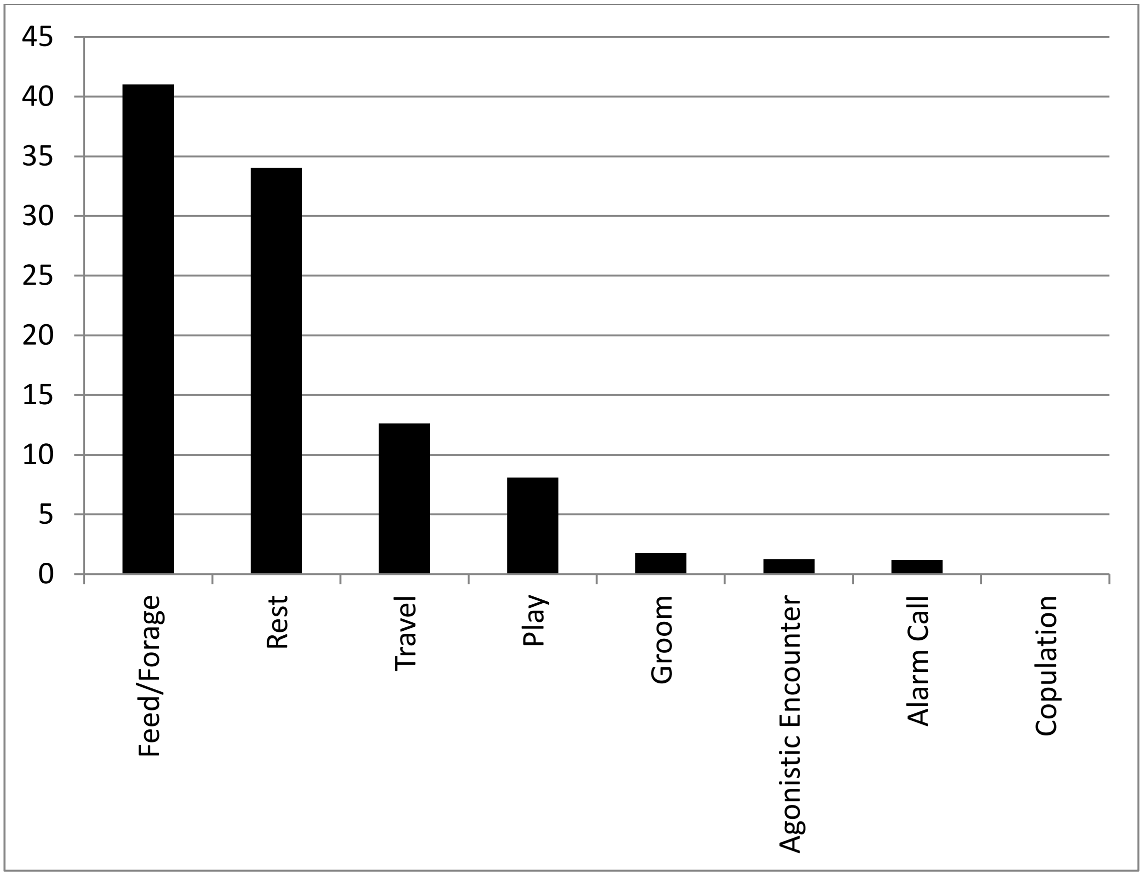

Fig 3.8. Bar graph depicting the proportion of each behavior for the activity budget over the study period. Each category is a percentage of the total observation hours for the study (406.9 hrs).

Additional Results

In addition to the analyses presented above I also performed a chi-squared test comparing the number of non-collared females with and without offspring to the number of collared females with and without offspring for the Jun-Aug 2013 study period and found no statistically significant difference ($\chi^2 = 2.201$, DF = 1, $p > 0.05$) (see Figure 3.9). There are 7 non-collared adult females and 6 collared females. All but one collared female had an associated offspring at the time the entire group was counted and all 7 non-collared adult females had an associated offspring.

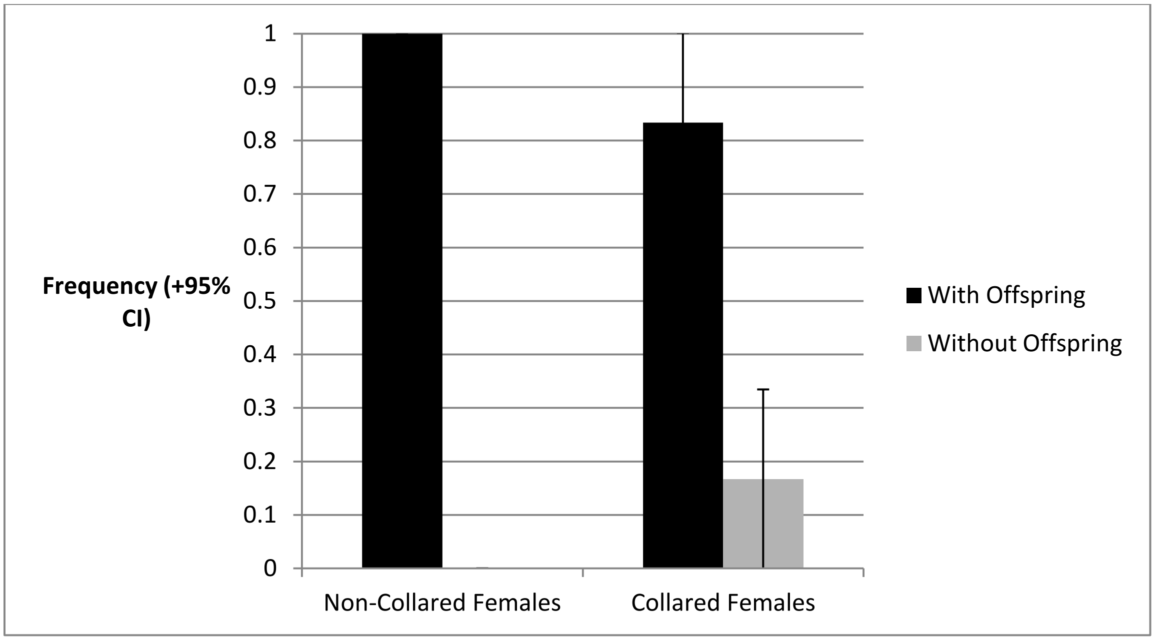

Fig 3.9. Graph showing the frequencies of non-collared and collared females with and without offspring witn 95 % CI (confidence interval) (see Table 9 for χ^2 results).

DISCUSSION AND CONCLUSIONS

The effect of collaring primates remains a poorly investigated problem in the field of primatology. The majority of studies investigating the effects of collaring have focused on birds, resulting in a lack of studies on mammals and especially non-human primates. In this study I aimed to investigate whether or not collars affect the grooming behavior of female black-handed spider monkeys (*Ateles geoffroyi*) on Barro Colorado Island (BCI), Panamá. It is widely accepted that, aside from maintaining proper hygiene, grooming has important social functions (Seyfarth 1983), including: maintaining social cohesiveness (Seyfarth 1983; Dunbar 1991; Pastor-Nieto 2001; Grueter et al. 2013), reducing tension within the group (Terry 1970; Schino et al. 1988), and aiding in the development and maintenance of consortships and alliances (Andelman 1986; Silk 1987). Grooming among *Ateles* species is highly influenced by their unique social structure which is characterized by high levels of fission-fusion dynamics or changes in "spatiotemporal cohesion" (Aureli and Schaffner 2008:236). This means that the larger social group splits into "parties or subgroups" that change in structure and composition throughout the day depending on how resources are distributed (Aureli and Schaffner 2008:236). Although grooming may be a relatively infrequent behavior observed within the genus *Ateles* and other New World primates, it remains one of the most important affinitive behaviors exhibited by these primates (Ahumada 1992; Pastor-Nieto 2001).

If the grooming behavior of female black-handed spider monkeys (*Ateles geoffroyi*) on BCI was being negatively impacted by the presence of collars (radio or GPS), one could predict that the collared females would exhibit significantly altered rates of grooming. Specifically, one might expect that collared females would exhibit a lower rate of allogrooming and a higher rate of auto-grooming (especially around the neck) than non-collared females. Conversely it could be predicted that collared females may exhibit significantly higher rates of all levels of grooming. Possibly other members of the group could recognize the irritation and provide more grooming to compensate.

The results of this study indicate that there appears to be no adverse effects on the grooming behavior of the female spider monkeys on BCI. The analyses show that collared females did not have a lower rate of grooming compared to non-collared females. Furthermore, collared females did not exhibit a higher rate of auto-grooming than non-collared females and did not show a preference for auto-grooming around the area of the neck (see Results). Additionally, collared females did not show evidence of a decreased rate of allogrooming in initiating or receiving compared to the non-collared females. These two points are particularly important. First, increased auto-grooming of the neck could indicate injury or irritation as a result of the collar, and secondly a decreased rate of allogrooming or social grooming in both initiating and receiving would suggest that there could be some level of social isolation experienced by the collared females due to the fact that social grooming is particularly important in maintaining group cohesion (Seyfarth 1983; Dunbar 1991; Pastor-Nieto 2001). As previously mentioned, social grooming is an extremely important behavior used in the maintenance of many primate societies. This study has shown that collared females do not appear to be social outcasts and are participating in both initiating and receiving social grooming just as frequently as their non-collared counterparts. The results of this study indicate that there is no difference in the duration of grooming bouts among collared and non-collared females. This adds credence to the assumption that the presence or absence of collars does not hinder the grooming behavior of the collared females.

It is important to highlight the fact that this study contains a small sample size and potentially is not representative of the grooming behavior of the six collared female black-handed spider monkeys (*Ateles geoffroyi*) on BCI. Early on during the study the telemetry equipment failed, making identification of each female incredibly difficult. During the first months of the study it was occasionally possible to identify the females through their unique collar frequency. Eventually, the collars stopped emitting their frequency which made achieving a representative focal follow dataset difficult. Therefore, it is hard to know whether or not the data were representative of all six collared females. The low number of focal follows and the inability to reliably know which female the focal follow was being conducted on made it difficult to know if the dataset collected for this study represents the behavior of all six collared females equally or is just representative of the behavior of a few of the collared females.

Despite the fact that grooming is an infrequently observed behavior in *Ateles* it remains an essential affiliative behavior (Ahumada 1992; Pastor-Nieto 2001). The results of the activity budget conducted for this study indicated, along the same lines as Ahumada's (1992) study conducted on the grooming behavior of the spider monkeys on BCI, that grooming truly is an infrequently observed behavior in this group of black-handed spider monkeys (*Ateles geoffroyi*). Ahumada's (1992) study revealed the grooming accounted for about 2.5 percent of their daily activities. This result is comparable to the study presented here where grooming accounted for 1.8 percent of their daily activities. Grueter et al. 2013 showed that the percentage of time spent grooming most often depends on the group size of the species in question, with the highest percentage of time spent grooming > 17 percent belonging to gelada baboons (*Theropithecus gelada*) which are known to have incredibly large groups of upwards of 145 individuals (Grueter et al. 2013). While black-handed spider monkeys (*Ateles geoffroyi*) may be at the lower end of the spectrum this is most likely due to the fact that they spend a great deal of time in smaller subgroups (Di Fiore et al. 2011). Grueter et al. 2013 study highlights the fact that although there is a great deal of variation in percentage of grooming among non-human primate species it is still one of the most prevalent behaviors exhibited across species.

When looking at the results of the remainder of the activity budget analysis we see that the overall patterns of behavior are in line with other studies that have investigated the activity patterns of this primate species. For example this study showed that this particular group of black-handed spider monkeys (*Ateles geoffroyi*) spent the majority of their time during the study period feeding/foraging and resting. Other studies have shown that feeding and foraging and resting account for the majority of activities in spider monkey (*Ateles*) groups in Columbia, Peru, Costa Rica, and on BCI (Klein 1972; Symington 1987; Chapman et al. 1989; Milton 1993; McDaniel 1994; Campbell 2000a). Traveling accounted for the next largest amount of time and frequently the other category accounted for the lowest percentage of the activity budget data across these studies (see Table 10 for detailed findings of these studies). The findings of this study, although much shorter than the previously mentioned studies, show similar results. This shows that this particular group of black-handed spider monkeys (*Ateles geoffroyi*) exhibits behavioral patterns comparable to groups elsewhere.

Table 10. Comparison of activity data for spider monkeys (*Ateles*) across eight studies (Modified from Campbell 2000a).

Reference	Rest %	Feed %	Travel %	Other %	Study Site
This study	34	41	12.6	12.2	BCI
Campbell 2000a	51.74	39.29	31.08	34.21	BCI
McDaniel 1994	31	25	41	3	Costa Rica (Hacienda Los Inocentes)
Milton 1993	50.1	25.6	18.7	2	BCI
Chapman et al. 1989	24.1	33.5	32.6	9.8	Costa Rica (Santa Rosa)
Symington 1988	45	29	26	< 1	Peru (Manu)
Klein 1972	44.4	27.4	28.2	N/A	Colombia

This study adds to the dearth of studies that have investigated the problem of possible behavioral effects of using collars. Furthermore it provides evidence in support of the contention that collars do not adversely affect the study animals that have been fitted with them. It is important to note that many of the studies that have investigated this problem have mostly centered their investigation on possible health effects rather than behavioral effects. I have shown here that the collars on the six female spider monkeys on BCI are inducing no adverse effects to their grooming behavior.

It is particularly important for researchers to understand how their investigative techniques could possibly impact their study subjects. Especially when considering that spider monkeys (*Ateles*), much like many non-human primates, are an endangered species in many of the countries they inhabit (Ramos-Fernandez and Wallace 2008). If researchers are implementing techniques that could potentially endanger the health and behavior of their research subjects then this could negatively impact conservation efforts. This study provides evidence that supports the idea that the benefit of collars outweighs any potential costs. Collars provide researchers with the ability to have more contact time with their study subjects which translates into the ability to collect more data. While this study shows that there are no significant results regarding the impact of collars on the grooming behavior of this particular group of black-handed spider monkeys (*Ateles geoffroyi*) and should help researchers feel more comfortable with using collars it may be worthwhile to conduct studies like this on many different primate species so that we can begin to get a very clear picture of how collars do or do not impact the health and or behavior of non-human primates.

It is my contention that the collars on the 6 black-handed spider monkey females (*Ateles geoffroyi*) on BCI are not negatively impacting their behavior. None of the results from this study were significant, showing that the grooming behavior was not being impacted by the collars. Even further evidence of this is the result showing that the number of collared females with and without offspring is not significantly different from the non-collared females. Also collared females were observed playing, copulating, and initiating agonistic encounters against other females which are by all accounts normal behaviors for these females to exhibit. This study indicates that the behavior of these monkeys is not being negatively impacted. Moreover, this study shows that when used correctly collars can provide a number of benefits to the researcher at little to no cost to the animal.

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