



USE OF ANVILS AND OTHER FEEDING BEHAVIOUR OBSERVED IN *CEBUS IMITATOR*, COIBA ISLAND, PANAMA

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ABSTRACT

Preliminary data of primate feeding behaviour on the continental island of Coiba was collected as a baseline study of feeding behaviour in *Cebus imitator* at coastal sites. Coiba Island is located on the South Pacific side of Panama, in the Chiriquí Gulf. It is a continental island and the biggest in the Mesoamerican region of the Pacific, it has an area of 503 km². This is a preliminary survey to identify basic feeding behaviour that could be measured in the future as a part of our ethogram to study *C. imitator*, as part of our long-term project on Coiba Island. We identified four feeding skills by *C. imitator* outside the forest: Hammering shells or skilled pounding, removing rocks, eating mangrove fruits, and pounding *Cocos nucifera* on an anvil. Using anvils seemed to be the most effective method to obtain food spending 51% of the time eating using this technique and only 28% moving to find a coconut, 18% invested in pounding the fruit, and just 3% on keeping vigil. Spending time outside the coast of a continental island seemed to be a beneficial technique for *C. imitator* to survive. Further studies will be conducted by Fundación Pro-Conservación de los Primates Panameños (FCPP) to understand the predation-feeding-competition theory and its implications for foraging techniques by *C. imitator* in an island habitat.

KEYWORDS

Anvils, behaviour, *Cebus imitator*, Coiba Island, feeding, Panama

USO DE YUNQUES Y OTROS COMPORTAMIENTOS DE ALIMENTACION OBSERVADOS EN *CEBUS IMITATOR*, ISLA COIBA, PANAMA

RESUMEN

Se colectó datos preliminares de comportamiento de alimentación en la isla continental de Coiba como un estudio base de comportamiento alimentario de *Cebus imitator* para las áreas costeras. Isla Coiba se encuentra en el lado Sur Pacífico de Panamá, en el Golfo de Chiriquí. Es una isla continental y la más grande en la región Mesoamericana del Pacífico, con un área de 503 km². Esta es una evaluación preliminar para identificar comportamientos de búsqueda de alimentos por *C. imitator* para un futuro etograma, como parte de nuestro proyecto de largo plazo en Isla Coiba. Identificamos cuatro técnicas utilizadas por *C. imitator* fuera del bosque: Martillando conchas, removiendo rocas, comiendo frutas de mangle, y rompiendo *Cocos nucifera* usando un yunque de piedra. El uso de un yunque de piedra pareció ser la forma más efectiva de conseguir comida con un 51% del tiempo comiendo, 28% moviéndose para buscar el coco, 18% estrellando el coco en el yunque, y un 3% de vigilancia. Invirtiendo tiempo en la zona costera continental parece ser una técnica beneficiosa en la subsistencia de *C. imitator*. Se realizará mayores estudios por la Fundación Pro-Conservación de los Primates Panameños (FCPP) para comprender la teoría relacionada a depredación-alimentación-competencia y sus aplicaciones en técnicas de forrajeo de *C. imitator* en hábitat de isla.

PALABRAS CLAVES

Alimentación, Comportamiento, *Cebus imitator*, Isla Coiba, Panamá, Yunques

INTRODUCTION

Physical cognition is a complex process where the individual relates space between two objects and performs an action to obtain a final result (Fragaszy *et al.*, 2004; Bird and Emery, 2009). Once thought to be primarily associated with *Homo sapiens*, physical cognition and tool use has been documented in great apes in a more primitive stage, and also in Neotropical primates, including *Cebus* spp. (Boinsky *et al.*, 2000; O'Malley & Fedigan, 2005; Waga *et al.*, 2006; Freitas & Biccamarques, 2009). However, there are still differences between making a tool (eg. *Pan troglodytes*, *Pongo pygmaeus*) and using impulsive elements from the field to achieve a result, mostly related

with food acquisition (O'Malley & Fedigan, 2005). For *Cebus*, the use of stones and anvils for cracking nuts around their home range is considered not as an adaptive, but a cognitive behaviour, possibly related with a cultural learning in familiar groups similar to the behaviour found in *P. pygmaeus* (O'Malley & Fedigan, 2005). In previous experiments on sensorimotor intelligence, *Cebus* showed superior intelligence compared with *Ateles* (6:4) using a Piaget's model to recognize whether they could be more "experimental and insightful" rather than using tools for fortuitous events of "trial and error" (Chevalier-Skolnikoff, 1989). Other behaviour showing their capacity for intelligence are: reaching food with a stick, throwing objects at other animals, "hunting in groups", anting, and learning using crops (Hernández-Camacho & Cooper, 1976; Longino, 1984; Chevalier-Skolnikoff, 1989; Loría & Méndez-Carvajal in prep.). Use of tools has been reported for *C. albifrons*, *C. capucinus*, *C. olivaceus*, *Sapajus apella*, *S. libidinosus* and *S. xanthosternos* (Westergaard & Suomi, 1994; Fragaszy & Boinsky, 1995; Boinsky *et al.*, 2000; Rodrigues-Canale *et al.*, 2009). *Cebus imitator* has been recently confirmed to be genetically distinct from *C. capucinus* (Boubli *et al.*, 2012). Here we report our observations on the use of stones to crack nuts by *C. imitator*, as previously reported for *C. capucinus imitator* in Costa Rica by O'Malley & Fedigan (2005).

In order to have baseline information for future projects related to *C. imitator* behaviour in a continental island habitat, we focus these observations to understand: Which are the basic behaviours to collect food by *C. imitator* in the coastal area of Coiba Island? We would like to understand the relationship among social group, hierarchy, and food processing behaviour in future projects, these results will help to clearly inform expected behavioural lists and our ethogram. Due to their complete isolation on Coiba Island, we are interested to learn more about the way *C. imitator* is surviving and whether a predation-feeding-competition theory (Wrangham, 1979), could be playing a role in their population dynamics.

METHODS

Study site

Coiba Island, located on the South Pacific side of Panama, in the Chiriquí Gulf, is a continental island and the biggest in Mesoamerican region of the Pacific with an area of 503 km² (Méndez-Carvajal, 2012). Coiba is mostly covered in primary tropical rain forest and two species of non-human primates; *Cebus imitator* (626 ind), IUCN-listed Vulnerable, and *Alouatta coibensis coibensis* (472 ind), endemic and listed as Endangered by IUCN (Méndez-Carvajal, 2012). FCPP has been monitoring these groups as part of a national long-term project to assess conservation status and population dynamics under permissions No.SE/A-99-10 and SE/A-70-12-16 from the Environmental Ministry of Panama (EMP). Ad-libitum observations were collected by PMC (2009; 2010) and SVD (2015), Indra Candanedo and Zuleika Pinzón as part of a regular surveillance with EMP. The observations were taken during three visits (25 days total) (Table 1), to obtain preliminary data of *C. imitator* feeding behaviour on the continental island of Coiba. To collect the information, we did observations combined with populations surveys, visited Coiba Island once per month between May and July 2009, with a total effort of 850 survey hrs per 30-day survey. Walking speed was 0.5 km/h with an approximate 10 min stop each 100 m. We revisited in May and September 2010, and October 2015. These surveys were taken from MiAmbiente Scientific Station, Cerro Equis, Playa Rosario, La Falla, and Los Pozos (Méndez-Carvajal, 2012). We walk along the coast every morning for 1 km in both directions from those central points from 06:00 to 08:00 hrs., and then for second time between 13:00 to 15:00 hrs. If group of *C. imitator* were found, we noted the date, the start and end time of the observations, age and sex (Oppenheimer, 1992). We classified different feeding patterns and when possible identified genus or species of the food eaten by the primate. Primates were filmed and photographed when possible, we filmed from a range of 10-25 m using a digital camera (Canon EOS 3ti) equipped with a 70-130 mm lens. Information was analysed using the digital clock on the film to obtain information on the time the animals spent on each behaviour. Central Tendency measurements were taken using Excel 2016. Percentages of time spent on each behaviour were calculated summarizing all the foraging

techniques observed. Even though we had vocalization information we did not consider this useable since recordings were sometimes drowned out by the sea natural sound.

RESULTS

The observations were done in three visits (25 days total), and are just a brief summary of the preliminary data of primate feeding behaviour in a continental island of Coiba. Here we report different activities of feeding behaviour for *C. imitator* in a coastal habitat. Using video observations, we measured the amount of time taken to consume food items using each method and evaluated the benefits of each technique (Table 1, 2). These preliminary observations serve as baseline data for more detailed investigations on tool use by *Cebus* spp., in the future.

Table 1 Comparison of four types of behaviour while eating and foreign by *Cebus imitator*, Coiba Island, Panama.

S	Type of behaviour	Eating (min)	Vigilant (min)	Moving (min)	Pounding food (min)	Time (min)	*Vocalization (min)	Not visible (min)	I/SG
1	Hitting gastropod against rock	0.18	0	0.25	0.09	0.54	0.03	0	I
2	Removing rocks, eating arthropods	0.08(9)	0.03 (19)	0.13 (4)	0	2.48	0.03	0.21	I
3	Removing rocks, eating arthropods	0.04 (2)	0.01 (2)	0	0.03	0.45	0.01	0	I
4	Hitting coconut against anvil	3.14	0.16	1.53	1.11	7.46	0.11	0	SG
5	Foraging at mangrove's canopy	0.09(2)	0.02	0.04	0	0.74	0	0	I
Total		3.54	0.22	1.95	1.23	6.94	0.18	2.1	
%		51	3	28	18				

S: Sample; Eating (n=15); Vigilant (n=23); Moving (7); Pounding (n=27)
*Activity of the individuals surrounded; I: Individual activity; G: Group activity

Table 2 Summary of behaviour using anvils technique by *C. imitator*, Coiba Island, Panama

Sample #	Pounding Coconut	Eating	Not visible	Vigilant	Moving	Observing	Vocalization	Time expended
4 (OM1)	0	0.75	0.57	0.07	1.05(4)	2.43(8)	0.07(2)	4.37
4 (FM)	0.77 (25)	2.80(10)	0	0.07	0	0	0.02	3.66
4(OM2)	0	0	0	0.02	0	1	0	2
4(OM3)	0	0	0	0	0	1	0	2
5(OM1)	0	0	0	0	0.24	0.02	0	0.26
5(FM)	0.23	0.24	0	0	0	0	0	0.47
5(OM2)	0	0.12	0	0	0.24	0.02	0.02	1.14
6(OM1)	0	0	0	0.11	0.07	0.19	0	0.37
6(FM)	0.11	0.08	0	0	0	0	0	0.19
6(OM2)	0	0	0	0.11	0.07	0.19	0	0.37
Totals	1.11	3.24	0.57	0.38	1.67	4.85	0.11	14.83
%	10	29	1	3	14	42	1	

OM: Observer monkey; FM: Focal monkey.

Feeding on Pelliciera rhizophora

The first event was in September 2012, in the mangroves near the entrance of the springs trail called “Pozos Termales” (07°27’13” N and 81°43’36” W), a group of five *C. imitator* were individually husking and eating *Pelliciera rhizophora* (observed by PMC and ID by Alicia Ibañez) (Méndez-Carvajal, 2012). This group seemed to prefer foraging at the coast as there are abundant food resources with high quality of nutrients, sometimes easier to detect and obtain compared with the forest. *C. imitator* have developed skills to easily open the fruits of *P. rhizophora* and achieve in three to four bites the opening of

the fruit and suck or eat quickly (4-8 seconds), part of the pulp, although the fruit are then released, this could be depending of the maturity of the fruit.

Six other tool-use techniques including pounding coconut on a stone, searching for arthropods by removing rocks, and hitting gastropods against rocks at the beach were observed (SVD, Indra Candanedo) in the main entrance mangroves forest near the scientific station of the Coiba National Park managed by the EMP (07°62'65" N and 81°72'82"W). Observations were done on October 16, 2015, between 09:00 hrs and 12:00 hrs, by filming a group of eight individuals of *C. imitator* six different times with distances between 10 to 25 m from the observer. The activities are as follows:

Pounding using Anvil stone for Cocos nucifera

Normally executed by an adult male surrounded by youngest males and adult females (Observer animal-OM), eventually able to steal some left over from the coconut (*C. nucifera*). The activity was done on a flat stone with sharp edges. The stone appeared to be not a natural structure, but rather, part of a piece of concrete left by the penal colony that closed in 2005. The procedures were mostly striking three times, using two hands to hold the fruit, and stopping to eat, revise and leave (Table 1). Eventually six of eight individuals from the group were paying attention to the one performing the activity (*i.e.* the focal animal – FM) and among one to four were located less than 1 m from the FM. The FM always performed this task while sitting or standing over the rock, never from the ground, and accompanied its movements with vigilance in its back and around while eating (Figure 1c, d). When eating, the FM eventually held the fruit with his rear leg. Interactions between the OM and FM were mixed. On some occasions, we observed OM members grabbing the tail of the FM and in some other occasions OM were sitting next to the FM with perfect tolerance. The later interaction is possibly due to a familiar and/or hierarchical relationship. The activity was performed simultaneously for other young males from the same group 20 meters from our first FM. We found husk remnants five meters from the anvil, which suggests the

animals harvest and pile part of the fruit in one place and ended up with the fruit in the anvil.

Fig. 1 *C. imitator* feeding behaviour outside the forest: a) Hammering or skilled pounding, b) removing rocks and eating, c and d) pounding *Cocos nucifera* on an anvil (c: Focal Monkey at right; d: Observer monkey at the left).



DISCUSSION

We identified four techniques used as feeding skills by *C. imitator* outside the forest, and separated them into five categories of behaviour: **a)** Hammering or skilled pounding, as defined by O'Malley and Fedigan (2005), where the animal repeatedly hammers a gastropod until breaking their shell to eat the content. This technique is different from that reported for *S. libidinosus* in Caatinga northern Brazil, which uses rocks to open shells (Ferrerira *et al.*, 2010); **b)** Removing rocks

and eating. This behaviour was used for arthropods as they do not have shells to remove. *C. imitator* ingests the prey soon after finding, eating in average of 0.03 sec. (SE±0.03, 0.02-0.43; n=10), to go for another; **c)** Eating mangrove fruits, also husking with the mouth and sucking content or biting (Méndez-Carvajal, 2012). All these were considered as an individual activity because each individual of the group perform it by themselves. The last category observed was **d)** pounding *C. nucifera* on an anvil. We categorized this as semi-group participation. Although this technique is performed by one individual, at least two or more individuals eventually get part of the leftover food without participating in the activity but observing. Participation in cooperative behaviour has been occasionally reported by *Cebus*; although more observations are needed to better describe this behaviour (Rose, 1997). Further, hunting in semi-cooperative individuals has been seen in Barro Colorado Island by Méndez-Carvajal (pers. Obs. in 1998), where four *Cebus*' individuals attacked and chased a group of crested guan *Penelope purpurascens*. Similar accounts of cooperative hunting by this species has been reported in Costa Rica (Fedigan, 1990; Janson & Boinsky, 1992).

Each of them presented some vigilance while foraging. This could be influenced by observer proximity. It is reported that *Cebus* primates perform foraging techniques more vigilantly when humans are nearby (Baldwin & Baldwin, 1977). Our observations indicated that vigilance of *C. imitator* increased when practicing the foraging techniques removing rocks and using anvils. Because these behaviours are performed on the ground, the increased vigilance prepared them to escape from possible predators (*H. sapiens*; *Crocodylus acutus*). Foraging and being vigilant is a common behaviour for *C. imitator* in forested areas, especially by individuals that are located at the external side of a group (Robinson, 1981). On Coiba Island there are no reports of *Cebus* being predated, as there are no reports of felines or eagles, however *Boa constrictor* and *Crocodylus acutus* could be mentioned as an eventual predator for coastal foraging. The lack of natural predators on the island could have led the *Cebus* groups to be smaller than reported elsewhere, and juveniles may not have learned to be as

defensive as primates that face natural predators following van-Schaik and van Hooff (1983). This is true if we compare the average group size of *C. imitator* on Barro Colorado Island, 17 ind/group (Phillips, 1995) with those on Coiba Island, 10 ind/group (Méndez-Carvajal, 2012). Vigilance was reduced when primates were in the mangrove's canopy, which could be related with the stratum used. In this case, primates will relate higher locations from ground as less risky, which is completely understandable for arboreal mammals (Isbell, 1994). As a preliminary result, the most successful technique was the use of stone as an anvil to break coconut, because it allowed *C. imitator* to obtain more food without walking long distances (taking into account the amount of nutritional elements in a coconut compared to other resources), expending then less energy, and allowing the participation of other members of the group, with possibilities of repetition. Percentages for the entire activities between being: vigilant, moving, eating, pounding and vocalizing suggested that the animals expends 3% of the time trying to avoid competition or predation, 28% opening and manipulating the fruit, vocalizing (was not considered as we missed information while collecting the sounds), as the main calls were exposed by other members around, however always present; and "eating" with 51% from the entire time observed (Table 1 and 2). For anvils technique, we reported three different observations, and reported benefits not only for the focal individual but also for the observers. Observers (OM) ate 26% of the time, while the focal individuals (FM) ate 96% of the time. *Cebus* have been reported to change foraging strategies depending on the food available, and is common to practice this behaviour alone if the resources are in a wide section of the forest (Phillips, 1995).

CONCLUSION

Continental coast areas in Coiba island seems to be productive for the *Cebus imitator* groups as a whole, but we noted that not all individuals look for food in the same way, and apparently few of them know very well how to proceed with anvils in particular. We observed mostly adult males practicing anvils technique, while juveniles or females walking to find food hammering and removing stones. Further

observations will be carried on to recognize how these strategies of foraging are influencing the groups of *C. imitator* on the island. This could be involving sexual differences or hierarchy, but it could be also supporting the predation-feeding-competition theory (Wragham, 1979), and its implications for foraging techniques by *Cebus* (van Schaik & van Hooff, 1983).

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