

## Original research

# First record of tool use by a wild population of *Cebus albifrons* (Humboldt, 1812) (Primates, Cebidae) in Puerto Misahuallí, Napo, Ecuador

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## ABSTRACT

At a national level, studies on ecology, behavior, and conservation status for *Cebus albifrons* species are limited. Just a few species of non-human primates have been recorded using tools in the wild. To obtain detailed observations of tool use we used an observation methodology adopted for this study aimed to record tool use occurrences for *Cebus albifrons* in 2011, 2017 and 2018 in Puerto Misahuallí in Napo, Ecuador in accordance with our protocol. It is based on data gathered through direct *ad libitum* observations, photographs, and videos from the study group. Adult and juvenile males use stones for nut-cracking (food extraction) and dig in

the sand, and manipulate man-made objects such as lighters and water bottles. This study allows us to report, for the first time, that *Cebus albifrons* (white-faced capuchin) is a species of primate that is skilled in the use of tools. This research analyzed the evidence produced to demonstrate that individuals of the *Cebus albifrons* species group can use different types of tools to achieve a specific objective.

**Key words.-** behavior, manipulation, nut-cracking, primates, urban wildlife.

## RESUMEN

A nivel nacional, los estudios sobre la ecología, el comportamiento y el estado de conservación de *Cebus albifrons* son limitados. Sólo unas pocas especies de primates no humanos han sido registradas usando herramientas en la naturaleza. Para obtener observaciones detalladas del uso de herramientas utilizamos una metodología de observación adoptada para este estudio destinada a registrar las ocurrencias de uso de herramientas para *Cebus albifrons* en 2011, 2017 y 2018 en Puerto Misahuallí en Napo, Ecuador de acuerdo con nuestro protocolo. Se basa en los datos recogidos a través de observaciones directas *ad libitum*, fotografías y vídeos del grupo de estudio. Los machos adultos y juveniles utilizan piedras para romper nueces (extracción de alimento) y cavan en la arena, y manipulan objetos artificiales como mecheros y botellas de agua. Este estudio nos permite informar, por primera vez, de que *Cebus albifrons* (capuchino de frente blanca) es una especie de primate hábil en el uso de herramientas. Esta investigación analizó las pruebas producidas para demostrar que los individuos del grupo de especies *Cebus albifrons* pueden utilizar diferentes tipos de herramientas para lograr un objetivo específico.

**Palabras Clave.-** comportamiento, manipulación, primates, rompe vidrios, vida silvestre urbana

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## INTRODUCTION

Tool use by animals is common and is defined as “the external employment of an unattached object to alter more efficiently the form, position or condition of another object, another organism, or the user itself, when the user holds and directly manipulates the tool during or prior to use and is responsible for the proper and effective orientation of the tool” (Shumaker et al., 2011). Animals have been recorded using tools for foraging (Bluff et al., 2010; King, 1986; McGrew & Rogers, 1983), sexual behaviour (Bagemihl, 1999; Falótico & Ottoni, 2013), and protection (Boinski, 1988). It is widespread among invertebrates (Finn et al., 2009) and vertebrates such as birds (Borsari & Ottoni, 2005; Hunt, 1996; Osuna-Mascaró & Auersperg, 2018; Rutz et al., 2016; Schuck-Paim et al., 2009; Tebbich et al., 2001; Wallace, 2000; Weir et al., 2002) and mammals (Hall & Schaller, 1964; Hart et al., 2001; Krützen et al., 2005; Nagano & Aoyama, 2017; Ralls et al., 2017).

Tool use by non-human primates was defined as a variety of different types of objects used sequentially to achieve a goal (Brewer & McGrew, 1990). Several species of Old-World and New World non-human primates use different types of tools (Table 1) in captive settings and in the wild. Tool use can be culturally unique. For example, the Tenkere chimpanzees (*Pan troglodytes verus*) (Alp, 1997), in Tenkere, Sierra Leone, use tools to feed on flowers and fruits of the Kapok tree (*Ceiba pentandra*). Thorns cover the branches of this species, which makes it difficult for chimpanzees to feed and leads them to use body parts as tools such as using the foot and the body as canes.

In New World non-human primates (NW NHP) only two genus of capuchins (*Cebus* and *Sapajus*) use tools in captive settings (Antinucci & Visalberghi, 1986; Fragaszy & Visalberghi, 1989) and in the wild (Aguiar et al., 2014). According to Boinski (1988), an adult male of *Cebus capucinus*, in Manuel Antonio National Park, Costa Rica, hit a poisonous snake (*Bothrops asper*) with a branch. The latter was the first direct observation of a New World primate recorded using tools.

**Table 1.** Tool use in Old World and New World Primates in captive and wild environments.

Primates	Species	Tool	Function	References
Catarrhini (Apes and Old-World Monkeys)	<i>Gorilla gorilla</i>	Branch Detached trunk	Walking stick Food extraction Self-made bridge	(Breuer et al., 2005)
	<i>Pan troglodytes</i> *	Sticks Stones Hammer Anvil Wiping handkerchief, Expelling stick Poking rod Branch	Honey Extraction Stepping-stick (as foot) Seat-stick (body protection) Nut-cracking Ant-gathering Ladder	(Boesch & Boesch, 1990) (Boesch et al., 2009) (Brewer & McGrew, 1990) (Alp, 1997) (Matsuzawa, 1996) (Nishida, 1973) (Sugiyama et al., 1993) (Takeshita & Van Hooff, 1996) (Menzel Jr, 1973) (Sumita et al., 1985) (Hannah & McGrew, 1987) (Inoue-Nakamura & Matsuzawa, 1997) (Kortlandt, 1986) (Matsuzawa, 1994)
	<i>Pan paniscus</i>	Leafy branches Sticks	Rain hat To reach things or other individuals	(Ingmanson, 1996) (Jordan, 1982)
	<i>Pongo pygmaeus</i> *	Leafs Stick	Using tool for sexual	(Van Schaik et al., 2003)

		Twig Live branches	stimulation Using tool to poke into tree holes to obtain social insects or their products Using tool to extract seeds Drinking water	(Van Schaik <i>et al.</i> , 1996)
	<i>Papio cynocephalus</i>	Paper	Liquid extraction	(Westergaard, 1992)
	<i>Papio papio</i>	Threaded steel rod	To rake in food.	(Beck, 1973)
	<i>Macaca fascicularis</i> * <i>Macaca fascicularis aurea</i> *	Hammerstones axe-shaped stones	To exploit sea snail, to crack rock oysters, detached gastropods, bivalves and swimming crabs	(Luncz <i>et al.</i> , 2019) (Falótico <i>et al.</i> , 2017) (Malaivijitnond <i>et al.</i> , 2007)
	<i>Macaca nemestrina</i>	A rod	To reach food	(Beck, 1976)
Platyrrhini (New-World Primates)	<i>Sapajus</i> sp.	Wood hammer and anvil Sponges	To pound an encapsulated seed  To obtain water inside tree trunk holes	(Aguiar <i>et al.</i> , 2014)
	<i>Sapajus apella</i> *	Stone hammers Wood Plastic twigs sticks	To open nuts extractive foraging techniques Mortar To open oysters To break seed to search coleoptera larvae	(Anderson, 1990) (De A. Moura & Lee, 2004) (Langguth & Alonso, 1997) (Fernandes, 1991) (Otoni & Mannu, 2001) (Rocha <i>et al.</i> , 1998)
	<i>Sapajus libidinosus</i> *	Stones hammers and anvils	To pound open defended food	(Haslam <i>et al.</i> , 2016)
	<i>Sapajus xanthosternos</i> *	Stones hammers and anvils	To open nuts	(Canale <i>et al.</i> , 2009)
	<i>Cebus capucinus</i> *	Branch	To hit a snake	(Boinski, 1988)
	<i>Cebus albifrons trinitaris</i> *	Leaves	To retrieve water from tree cavities	(Phillips, 1998)

Note: \*species recorded using tools in the wild.

The white-fronted capuchin *Cebus albifrons* is a medium-sized primate belonging to the family Cebidae (Eisenberg & Redford, 1999), whose geographical range includes several countries in South America: Bolivia, Brazil, Colombia, Ecuador, Peru and Venezuela (Emmons & Feer, 1997). In Ecuador, this species is found in the western Ecuadorian Amazon (Tirira, 2007). Its conservation status is of Least

Concern (De la Torre et al., 2015). Studies on the ecology, behaviour and health of *Cebus albifrons* are limited (Defler, 1979; Martin-Solano et al., 2017; Pozo R., 2004). The species is located in regions of the forest with a high-density biomass (Tello, 2003). One of the main threats to the white-fronted capuchins (*Cebus albifrons*), are habitat deterioration (Nuñez-Iturri & Howe, 2007), bush meat hunting (MAE, 2013), and pet trade. In 2013, 14 species of mammals were trafficked; the most trafficked being white capuchin (*Cebus albifrons*), with 19 confiscated specimens by the Ministry of the Environment (MAE, 2013).

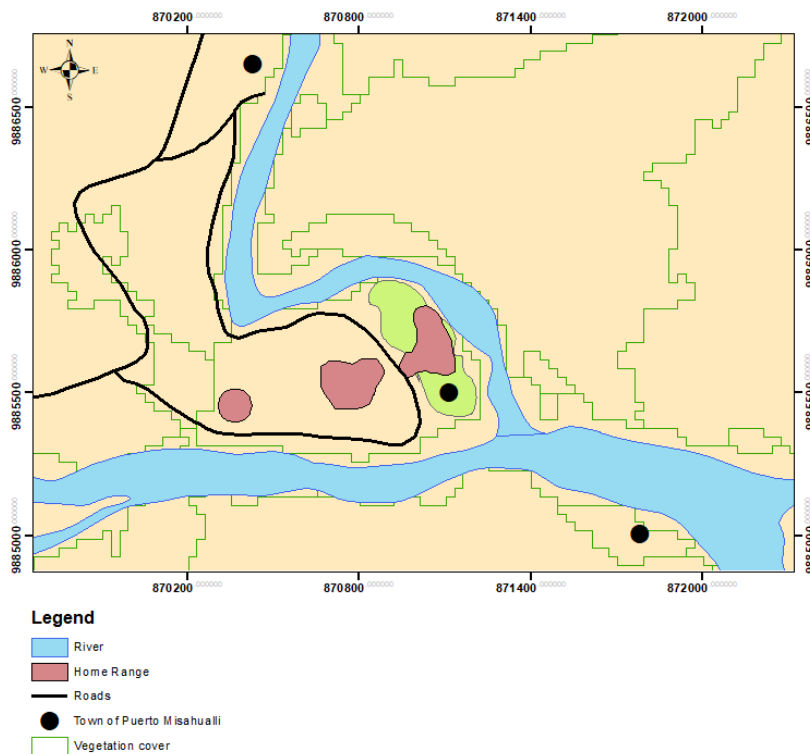
Just a few species (n = 9) of NHP have been recorded using tools in the wild, therefore an increase of studies of tool use in the wild by NHP will contribute to understand the evolution of primate behavioural and cultural traditions. The aim of this study was to record the use of tools in a free-ranging group of *Cebus albifrons* from the Ecuadorian Amazon to provide new behavioural data on this species and to provide references regarding the evolution of tool use in primates.

## METHODS

**Study site.**-We collected data at Puerto Misahuallí (01 ° 02 '07.0 "S, 77 ° 39' 59.4" W, 571 m.a.s.l.), a small town of 513 km<sup>2</sup> of Tena, Napo Province, in the Ecuadorian Amazon. The research site is an anthropic environment with an average monthly precipitation of 407 mm and an average temperature of 23.8 °C according to the National Institute of Meteorology and Hydrology (INAMHI, 2014). The town has a park and a forest patch.

**Study group.**- The number of individuals in the study group varied over the time range in which observation records were made (2011-2018). We collected data from a group of 15 individuals of *Cebus albifrons* at the beginning of the study, and at this time there are 8 individuals. The home range of this group is about 2.04 ha (Fig. 1) (Martin-Solano et al., 2017). This group is provisioned by locals occasionally and by tourists when they come to visit the park. They raid for human food and consume human leftovers as well (Castro, 2019), but also forage for natural food in the forest patch.

**Study period and sampling.**- Between March 2011 and October 2018, we collected behavioural data from a total of 15 free-ranging individuals of *Cebus albifrons*. Individuals were followed daily from 06:00 to 18:00 hours. The observation methodology used for this study was the recording of *ad libitum* occurrences in 2011, 2017 and 2018 during the focal observations (we used a 20-minute focal sampling (Altmann, 1974) for each individual). We took direct photographs and record videos of the group of individuals of *Cebus albifrons* when they were using tools. We made detailed observations because we were able to observe the capuchins from a short distance (< 1.0 m). We followed the definition of tool-use defined by Shumaker et al. (2011). We define behavioural categories (stones and anthropic objects) of tool use according to *ad libitum* observations.



**Figure 1.** Home range of *Cebus albifrons* in Misahuallí, Napo.

## RESULTS

We observed a total of 16 *ad libitum* tool-use events in the *Cebus albifrons* group of Puerto Misahuallí. In eight of those 16 events, we observed the use of natural tools (stones) in 2017 ( $n = 3$ ) and in 2018 ( $n = 4$ ). We observed only males, adults, and juveniles, using stones as hammers ( $n = 3$ ) (Fig. 2 a, c, d, and e), and as hammers and anvils ( $n = 1$ ) (Fig. 2.b.) for two different purposes: one of the purposes was to dig in the sand, and the second one for food extraction (to grind an almond tree fruit from the species *Terminalia catappa*). In two events the individual repeated the process with three more almond trees fruits.

On the remaining eight events we observed the use and manipulation of anthropic objects such as a lighter and a plastic bottle (Fig. 3). All individuals were males. When adults used a lighter, they were able to keep it lit on and bring it closer to their chest, to burn their fur. They did this repeatedly. We also observed juveniles manipulating lighters, however they were not able to keep it lit on. As for the use of water bottles, one adult and one juvenile were observed in independent events manipulating the bottle cap with their hands until they managed to open it. Once opened, they drank the water remaining in the bottle. Finally, we observed a juvenile drinking water from a tap he managed to open.



**Figure 2.** a) Alfa male using a flat stone, b) A juvenile of *Cebus albifrons* using two stones one as a hammer and the other as an anvil to crush a coconut, c) A juvenile hitting an almond fruit on a bench in the park of Puerto Misahuallí, Napo. d) A juvenile rolling a stone to crush a fruit in the Park of Puerto Misahualli, Napo, e) A juvenile crushing an almond fruit with a stone under a bench.



**Figure 3.** Use of a lighter, a) A subadult burning his lower extremity with a lighter, b) Burning of the lower extremity with a lighter by the adult alpha male, c) An adult burning his lower extremity with a lighter, d) **Manipulation of other anthropic objects:** A juvenile drinking water from a bottle.

## DISCUSSION

This is the first direct observation record of the customary use of tools (stones and anthropic objects) recorded for the species *Cebus albifrons* in the wild. Similar behaviours have already been observed in other species of capuchins: the white-faced capuchin (*Cebus capucinus*) (Boinski, 1988), and the tufted capuchin (*Sapajus apella*) (Anderson, 1990; Antinucci & Visalberghi, 1986; Fragaszy & Visalberghi, 1989; Ottoni & Mannu, 2001; Westergaard & Fragaszy, 1987). The number of anvil sites is limited to one area because the home range of this group is small, and it is the only group known to be present in that area. According to McGrew and Marchant (1997), dozens of publications on primate tool use in the wild and in

captivity have been carried out and indicate that the genus *Cebus* spp. and *Sapajus* spp. in NW NHP (Cebidae, Platyrrhini) and *Pan* spp. in OW NHP (Hominidae, Catarrhini) use tools more than any other species.

The use of stones in animals is not surprising, sea otters (Haslam et al., 2019), birds (Barcell, 2015), fish (Jones et al., 2011), and even spiders (Henschel, 1995) can use them as well. In OW NHP, the use of stones has been observed in a few species (Falótico et al., 2017; Malaivijitnond et al., 2007; McGrew & Marchant, 1997; Proffitt et al., 2018; Tan et al., 2015), but one group in particular, stands out in Boussou (South-eastern Guinea): primates transport the stones from one anvil site to another even if there are stones available there (Carvalho et al., 2009). In our research site we have not yet observed the transportation of tools from one site to the other. In NW NHP, stone tools have been registered in bearded capuchins (*Sapajus libidinosus*) dating back from 600 to 700 years ago (Haslam et al., 2016). However, just a few direct observations were made of bearded capuchins using stones in the wild (De A. Moura & Lee, 2004; Fragaszy et al., 2004). According to Matsuzawa's tool use classification, we can classify one of the events where stones were used (the third event in February 2017) as pertaining to level 2 (Matsuzawa, 1996), because there are three objects incorporated in the action: the stone (the hammer), the anvil (the substrate stone), and the coconut. This behaviour was already observed in bearded capuchins (*Sapajus libidinosus*) (Fragaszy et al., 2004) but not on *Cebus* spp. Visalberghi and Trinca (1989) argue that capuchin monkeys do not mentally represent their tool-use actions. The authors base this assertion on the finding that capuchins select inappropriate objects and attempt to use them as tools even though they had previously selected appropriate objects and used them properly to secure food. In this study a juvenile *Cebus albifrons* behaved in the same way when trying to open an almond tree fruit with a stone that exceeded the appropriate size to perform the task. Many questions regarding stone-tool use have been raised and we should emphasize on this subject matter to preserve this specific group and their habitat.

The use of tools in NHP has been recorded in both males (Fernandes, 1991) and females (Benito-Calvo et al., 2015; Breuer et al., 2005) NHPs. In chimpanzees there is a female/male bias (Koops et al., 2015). De A. Moura and Lee (2010) and Falótico and Ottoni (2014) found that both, males and females of *Sapajus libidinosus* species, use tools, however males use them more than females. In our study we only found males performing the actions whereas females were just observers. A total of six different males were observed using natural and anthropic tools.

This study allowed us to confirm that our study group of the species *Cebus albifrons* used stones to break nuts and extract the internal flesh. This behaviour was similar both in form and function to the behaviour reported for chimpanzees (Boesch & Boesch, 1990; Sakura & Matsuzawa, 1991) on similar occasions. However we did not report the use of probe tools as was mentioned already in wild tufted capuchins (Falótico & Ottoni, 2014). Additional to this contribution, *Cebus albifrons* was observed making use of an unusual tool for non-human primates, the lighter, which can be attributed to the urban habitat where they live. The anthropic



environment contributes, in this case, to the use of tools (Aguiar et al., 2014). The use of man-made tools may be a result of the *Cebus*' observations of human manipulations. Juvenile used the lighter the least number of times, since immature primates (Westergaard & Suomi, 1993) acquire the use of tools through a less advanced cognitive process than that which occurs in adult monkeys (Westergaard & Fragaszy, 1987). They probably learn through the improvement of the technique (Fragaszy & Visalberghi, 1989), as we observed that the use of stones was not the same among juveniles.

Laterality in hand use has been observed in some species (Humble & Matsuzawa, 2009; Moura, 2015). For hand preference, this study group had a tendency of using both hands when handling large stones. However, when small stones were available one juvenile was observed using his right hand to pick them up. The Alpha males showed ambipreference for turning the lighter on. For example, one alpha male used his right hand once (event) as well as his left hand at a different time (event). McGrew and Marchant (1997) found that *Cebus* spp. showed a preference for one specific hand. Because the number of events in our study is limited, increased time to observations and a larger sample size could help us to determine hand preference.

## CONCLUSION

This research has analysed the evidence recorded in Puerto Misahuallí (Tena, Napo) to demonstrate that individuals of the species *Cebus albifrons* are able to use different types of tools to achieve an objective. As a continuation of this study, it would be interesting to mark the stones used as tools to further enrich the research process and to determine whether the same stones are being used to fulfil the tasks or whether they choose tools randomly (Gumert & Malaivijitnond, 2013; Tan et al., 2015). Another recommendation would be to measure or analyse the size and form of the stones by means of morphometrics to establish whether there is an underlying preference to use them (Benito-Calvo et al., 2015). Finally, we encourage the local environmental authorities of the Ministerio de Ambiente, Agua y Transición Ecológica to conserve this HNP population for its scientific value.

**Conflicts of interest:** There were no conflicts of interest during the execution of this research.

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