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NEWS AND PERSPECTIVES

# Extraction of hermit crabs from their shells by white-faced capuchin monkeys (*Cebus capucinus*)

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**Abstract** We observed two capuchin monkeys (*Cebus capucinus*) feeding on hermit crabs (*Coenobita compressus*) on the coast, and the tactics they used to extract this well-protected prey. The observations took place during the dry season at Playa Escondida beach, Puntarenas, Costa Rica. The capuchins descended from trees at the back edge of the beach to capture passing hermit crabs. Both capuchins extracted the hermit crabs from their protective shells by holding the shell with one hand and pulling the crab out with the other. Even though this was accomplished within seconds, the extraction of hermit crabs from their shells did not appear to be a straightforward task. Once the capuchins succeeded in pulling the crabs out of their shells, they consumed the soft abdomen and discarded the rest of the crab's body. To our knowledge, the consumption of hermit crabs has not been previously reported for any capuchin monkey (*Cebus* or *Sapajus*). Our observations provide a new example of extractive foraging by capuchins, and thus an additional natural context for which fine motor skills (which are highly developed in capuchins) are necessary.

**Keywords** Primates · Diet · Embedded food · Dexterous manipulation · Costa Rica · Coastal habitat

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## Introduction

The monophyletic group of new world primates in the genera *Cebus* and *Sapajus* (all previously grouped under the genus *Cebus*) are collectively known as 'capuchin monkeys' (Alfaro et al. 2012). The diet of capuchin monkeys has been studied in considerable detail and under natural conditions (e.g., Freese and Oppenheimer 1981; Robinson 1986; Janson and Boinski 1992; also see Fragaszy et al. 2004), most studies focusing on *C. capucinus* and *S. apella* (Fragaszy et al. 2004; Alfaro et al. 2012). Capuchin monkeys in general are classified as omnivores, although their diets can vary considerably among different populations and environments (Fragaszy et al. 2004). For instance, one studied population of white-faced capuchins (*C. capucinus*) relied mainly on fruit, whereas an adjacent population relied strongly on insects (Chapman and Fedigan 1990). Also, for both *Cebus* and *Sapajus,* diet can vary markedly across seasons, depending on the availability of different food items (Robinson 1986; Fragaszy et al. 2004), and it is usually during the dry season that they resort to alternate, less-preferred food sources (see Fragaszy et al. 2004).

In addition to consuming a great variety of soft pulpy fruits, capuchins (both *Cebus* and *Sapajus*) are known to exploit a myriad of other food sources, such as flowers and nectar, soft insect larvae, leaf bases of bromeliads, hard-shelled fruits, wind-dispersed seeds, palm nuts and piths, and hard chitinous arthropods (Freese 1983; Robinson 1986; Fragaszy et al. 2004). They also consume a wide variety of vertebrate prey such as eggs, small mammals, birds, frogs, and lizards (Fedigan 1990; Fragaszy et al. 2004). The flexibility of capuchins in regard to diet has no doubt contributed to their ability to occupy different types of Neotropical habitats (Fragaszy et al. 2004). These traits

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may also help to explain why some capuchins manage to survive in areas severely altered by anthropogenic activities (Mckinney 2011; Campbell 2013).

Even though *C. capucinus* inhabits coastal land (Chapman and Fedigan 1990; Panger et al. 2002), and most studies of this species have been conducted in areas with coastal environments, the published observations have focused on habitat away from the coast (Chapman and Fedigan 1990; Panger et al. 2002; Carnegie et al. 2011; also see Fragaszy et al. 2004). Therefore, the diet of *C. capucinus,* one of the most studied species of capuchins, has been mainly described from non-coastal habitats. Here we report *C. capucinus* feeding on hermit crabs on the coast, and describe their particular tactic to extract this otherwise well-protected prey. Even though other species of *Cebus* and *Sapajus* also inhabit coastal land (Fragaszy et al. 2004; Alfaro et al. 2012), and at least three species in these genera have been reported to feed on crabs (Port-Carvalho et al. 2004; Mckinney 2011; Cutrim 2013), to our knowledge, the consumption of hermit crabs has not been previously reported for any capuchin monkey.

## Methods

The observations took place during the dry season at Playa Escondida (9°39′52″N, 84°40′17″W), Puntarenas, a small beach (approximately 270 m of coastline) on the central Pacific coast of Costa Rica. The climate of this region is characterized by a marked but short 3-month dry season, followed by a 9-month wet season, with an annual precipitation of approximately 3100 mm and an average monthly temperature of 28 °C (Solano-Quintero and Villalobos-Flores 2001). The maximum and minimum recorded temperatures on the day the observations were made were 31 and 19 °C, respectively. This region is considered a transition zone between Costa Rica's dry North Pacific and its wet South Pacific, with evergreen forests dominating the landscape (Jiménez and Carrillo 2016).

The area around Playa Escondida beach has been partially deforested for the construction of apartment complexes, but still holds a fair amount of forest cover. On a regional scale, however, the landscape is highly fragmented, with scattered patches of forest embedded within pastures, agricultural fields, and urban areas (Jiménez and Carrillo 2016). At Playa Escondida, the terrain descends steeply to the coast, and the forest ends abruptly at the sandy beach, with no mangroves or swamps in between. Most of the buildings are located 20 m or more behind the beach, leaving a strip of characteristic coastal vegetation dominated by palms and the tree species *Terminalia catappa* and *Plumeria rubra*. Our observations were on a pair of wild capuchins (*Cebus capucinus*) that happened to pass by very close to where we were sitting at the beach.

## Results

On 11 March 2016, at 4:30 p.m., we observed a pair of adult capuchins (*Cebus capucinus*) of unknown sex, travelling across the treetops on the steep hill adjacent to the beach. After approximately 15 min of travelling and presumably foraging on the treetops, both monkeys had gradually descended to the forest floor, approximately 5 m away from the sand where we were located. The capuchins spent some time at the same site, switching between being on the floor and ascending short distances (0.5–2 m) up nearby trees. We had already noticed that there were dozens of hermit crabs (*Coenobita compressus*) moving from the beach uphill into the forest (a fairly common behavior of these crabs along beaches in the country). However, we had not yet noticed that the monkeys had descended to the specific spot (about 3 m wide) where the hermit crabs were passing through. After careful inspection, we noted that both capuchins were feeding more or less continuously on hermit crabs, as detailed below.

Both capuchins were observed to grab hermit crabs off the ground, one at a time, either by standing directly on the forest floor, or by reaching from the surrounding vegetation. After grabbing a hermit crab, the capuchins quickly climbed up the vegetation (0.5–2 m), where they proceeded to pull the crab out of its protective shell while sitting on a branch or tree fork. To extract the crab, the capuchins held the shell with one hand and pulled it out with the other. Even though this operation was always successful and completed within a few seconds, we got the impression that it was not straightforward. Capuchins repeatedly touched the crab with the extracting hand and immediately withdrew it in an abrupt manner, sometimes two to three times in succession. Also, prior to extracting the crabs from their shells, the monkeys were occasionally seen switching the crabs from one hand to the other (this might suggest that the crabs were defending themselves with pinches). When the capuchins succeeded in pulling a crab out of its shell, they immediately consumed the soft abdomen by biting it off while holding the crab with one hand. Immediately after consuming the abdomen, the capuchins dropped the crab's body and its shell to the ground.

By standing downhill, we retrieved crab bodies and empty shells that rolled to the beach. The partially consumed crabs continued to walk for a short while, but died some minutes after (from five partially consumed crabs that we monitored, the one that remained alive the longest was a large individual that died approximately 20 min after its

abdomen was bitten off). The crabs consumed by the capuchins were of various sizes (Fig. 1). Of the crab bodies that we inspected ($n = 8$), we found all to be missing the abdomen and none to be missing the chelipeds. Only a couple of small crabs were also missing legs (Fig. 1), presumably from the monkeys' bite, although it is also possible that the legs were broken off while the monkeys attempted to extract the crabs from the shells.

Both capuchins remained at the site for approximately 40 min, intermittently descending from the trees to

**Fig. 1** Three hermit crabs (*Coenobita compressus*) that died after having their abdomens eaten by *Cebus capucinus* at Playa Escondida beach, Costa Rica. Note that all crabs have intact chelipeds, and only the crab at the top left has missing legs. The *scale bar* measures 23 mm

consume the hermit crabs. We estimated that the capuchins consumed more than ten hermit crabs each during this period, and possibly double this amount. During our observations, we occasionally approached closer (less than 5 m away), and this caused the capuchins to interrupt their feeding bouts momentarily (for <5 min). On one of these occasions, near the end of the observation period, one of the capuchins stared and displayed aggressive behavior (bared its teeth, growled, and shook the branch it was sitting on) until we retreated some meters away. Immediately after, the capuchins resumed their foraging, descending to the ground and capturing more hermit crabs. Both capuchins remained at the site after we left (at 5:30 pm). We visited the same site during the next 2 days at approximately the same time of day, but we did not observe any capuchins or hermit crabs.

## Discussion

To our knowledge, this is the first report of a species of capuchin preying upon hermit crabs. Even though extraordinary effort has been devoted to describing the diet of capuchins in general (see Fragaszy et al. 2004), most studies have focused on non-coastal habitats. However, several species of capuchins inhabit varied coastal habitats such as mangroves, swamps, and beach-bordering forests (Panger et al. 2002; Fragaszy et al. 2004; Alfaro et al. 2012). Given that the diet of capuchins is very flexible and can vary markedly among sites (Chapman and Fedigan 1990; Fragaszy et al. 2004), it would be worthwhile to study in further detail the diet of those populations living in coastal habitats. An important endeavor in this direction has already revealed interesting differences in behavior and diet in populations of *Sapajus libidinosus* inhabiting mangroves, in comparison to populations living in other habitats (Cutrim 2013). In the case of *Cebus capucinus,* such studies would also document whether hermit crabs are an important dietary component for coastal populations in general, or whether their consumption represents individual specialization (Bolnick et al. 2003).

There have been other reports about the predation of crabs (non-hermits) or other types of coastal invertebrates (see below) by capuchins, but often, as in our case, such reports are based on a few observations, or the observations did not constitute the main focus of the study (see Cutrim 2013 for an exception). For instance, *C. capucinus* has been reported to consume crabs (non-hermits) and a variety of mollusks in a mangrove habitat (McKinney 2011; McKinney pers. comm.), and *Sapajus apella* has been observed consuming forest crabs in eastern Amazonia (Port-Carvalho et al. 2004). Individuals of these species have also been reported to consume oysters in coastal habitats (Fernandes 1991; see Freese 1983). However, follow-up research on such observations is necessary to understand the broader aspects of capuchin ecology. For instance, relying on coastal food during the dry season could be a way by which some populations of capuchins confront this otherwise lean time of the year, when fruits and insect larvae are scarce in adjacent forests (Freese 1983).

This study contributes to the generally known fact that capuchin monkeys are extractive foragers. That is, they routinely access concealed food items through particular behaviors such as digging, splitting branches, cracking open hard fruits, or rolling logs over (Freese 1983; Fragaszy et al. 2004; Moura and Lee 2004). Our observations also support the reputation of capuchins as "bold" foragers, who often target well-defended prey such as bees' or wasps' nests, and routinely poke their hands and arms inside holes and crevices (Fragaszy et al. 2004).

Even though capuchins (both *Cebus* and *Sapajus*) commonly open hard-shelled fruits by banging them against a hard surface (Fragaszy et al. 2004), and some populations of *Sapajus* routinely use tools to crush-open nuts or shells (Fernandes 1991, Moura and Lee 2004; Ottoni and Izar 2008; Cutrim 2013), the capuchins we observed did not extract the hermit crabs in such a destructive manner. Instead, they pulled the crabs out of their shells with their hands. Hermit crabs use gastropod shells as a protective covering (Hazlett 1981), so it is interesting that whereas *S. libidinosus* uses tools (pieces of wood) to crush-open the shells of gastropods and other mollusks (Cutrim 2013), the *C. capucinus* we observed did not. Similarly, *Macaca fascicularis* uses stone tools to crush-open a variety of mollusks (including gastropods) and other seafood (Gumert and Malaivijitnond 2012). It is possible that hermit crabs are easier to extract from shells than are gastropods. Hermit crabs can only seldom retreat deep into their shell (pers. obs.), and they have hard claws and legs that the capuchins can grab and pull, whereas gastropods can retreat deeper into their shells and leave no protruding body parts, making extraction seemingly difficult without the use of tools.

The extraction and consumption of hermit crabs by *C. capucinus* resembles more the tool-less procedure used by *S. libidinosus* to eat crabs (non-hermits), which consisted of carrying the crab up a tree and dismembering it with the hands and mouth to consume its soft parts (Cutrim 2013). It is possible that the use of tools might be favored when access by other means (e.g., extraction with fingers or banging against a hard surface) is not possible. However, *S. libidinosus* can prey upon non-hermit crabs in the manner described above, and they can also crush them open with the use of tools (hitting the crab with a piece of wood against a wooden "anvil") (Cutrim 2013). For such

facultative tool users, it would be useful to determine which factors favor the use of tools.

The capuchins from our study solved the challenge of pulling the hermit crabs out of their protective shells with apparent ease. Capuchins are known for their dexterous control of hand and finger movements while extracting and processing food items (Fragaszy et al. 2004). Such dexterity appears to be unique among the New World primates, and might be related to their problem-solving abilities (Visalberghi and Trinca 1989; Fragaszy et al. 2004). As Fragaszy and colleagues (2004) suggest, it would be worthwhile to document in detail the fine motor skills used by capuchins to extract embedded food items such as hermit crabs and other concealed foods, in order to understand the fine motor challenges these monkeys face under natural conditions.

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