

Brown-tailed Vontsira *Salanoia concolor* (Eupleridae) documented in Makira Natural Park, Madagascar: new insights on distribution and camera-trap success

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Abstract

Photographic evidence of Brown-tailed Vontsira *Salanoia concolor* within the Makira Natural Park, northeastern Madagascar, extends the species's known range north and west 60–70 km from previous records and expands its maximum known elevation some 30 m higher, to a recorded elevation of 680 m. *Salanoia concolor* was photographed during two camera-trap surveys (2008, 2010) in the Anjanaharibe region (15°12'09"S, 49°37'20"E) of Makira Natural Park at a total of 10 camera-stations across a 20-station (2008) and 25-station (2010) grid. In addition, *S. concolor* was camera-trapped at four stations within a new camera grid located at 15°16'52"S, 49°46'04"E, 15 km southeast of the Anjanaharibe study site, within degraded forest near the villages of Andongana and Sahavary. *Salanoia concolor* captures and camera-trap success decreased from the 2008 survey (N = 10 and 0.8, SE ± 0.2, respectively) to 2010 (N = 4 and 0.6, SE ± 0.4, respectively). Co-occurrence of *Salanoia concolor* with humans and with domestic dogs *Canis familiaris* was minimal. Likewise, camera-stations recording *S. concolor* did not overlap with those few recording introduced cats *Felis silvestris* and/or *F. catus* (three) or the introduced Small Indian Civet *Viverricula indica* (one). These observations suggest efforts are needed to minimise human encroachment, and to control the spread of introduced carnivores within the natural park.

Keywords: Anjanaharibe forest, introduced carnivores, Malagasy carnivores, photographic sampling

Ny Vontsira Mainty *Salanoia concolor* (Eupleridae) hita tao amin'ny Valanjavaboary Makira: fari-ponenana sy taham-pikarohana vaovao

Famintinana

Ny raki-tsary manaporofa ny fisian'ny Vontsira Mainty *Salanoia concolor* ao amin'ny Valanjavaboary Makira, any avaratra atsinanan'i Madagasikara, dia nahafantarana fa miitatra hatrany amin'ny 60–70 km mianavaratra sy miankandrefan'ny faritra voamarika teo aloha ny faritra itoeran'io karazam-biby io, ary miampy 30 m ny haavo itoerany raha 680 m ny ambony indrindra voarakitra teo aloha. Nandritra ny fikarohana indroa miantoana (2008 sy 2010) natao tao amin'ny faritr'Anjanaharibe (15°12'09"S, 49°37'20"E), dia toerana 10 tamin'ireo toerana 20 (tamin'ny 2008) sy toerana 25 (tamin'ny 2010) nametrahana fakan-tsary no nahitana ny Vontsira Mainty. Nahitana azy ihany koa ny toerana efatra hafa tao amin'ny ala simba manakaiky ny tanànan'Andongona sy Sahavary any amin'ny 15 km atsimo atsinanan'ny toeram-pikarohana ao Anjanaharibe. Nihena ny isan'ny sarim-Bontsira Mainty azo sy ny taham-pahombiazana nandritra ny fikarohana tamin'ny taona 2010 (sary azo = 4; taham-pahombiazana = 0,6) raha miohatra amin'ny fikarohana natao tamin'ny taona 2008 (sary azo = 10; taham-pahombiazana = 0,8). Ity fikarohana ity dia nahatsapana fa vitsy dia vitsy ny *Salanoia concolor* hita tamin'ireo toerana ivezivezen'ny olona sy ny alika *Canis familiaris*. Ary tsy mifanindry amin'ireo toerana nahitana saka-dia vahiny *Felis silvestris* sy/na *F. catus* (telo) na ny karazan-jaboady vahiny *Viverricula indica* (iray) ny toerana nahitana ny Vontsirasavoka. Izany rehetra izany no milaza fa ezaka lehibe no ilaina mba hampihenana ny fivezivezen'ny olona sy ny fiparitahan'ireo biby vahiny mpihinan-kena manta manerana ny Valanjavaboary.

Introduction

The genus *Salanoia* has two species, Brown-tailed Vontsira *S. concolor* (also known as Brown-tailed Mongoose) and the newly discovered Durrell's Vontsira *S. durrelli* (Durbin *et al.*, 2010). These are possibly the least known of Madagascar's species of endemic carnivores, which are all in the endemic family Eupleridae (Schreiber *et al.* 1989, Hawkins *et al.* 2008, Goodman 2012). *Salanoia concolor* is listed as Vulnerable by the *The IUCN Red List of Threatened Species* (Hawkins *et al.* 2008) and is believed to be restricted to northeastern rainforests below 650 m (Hawkins *et al.* 2008, Hawkins 2012), while the recently discovered *S. durrelli* has only been found around Lac Alaotra (Durbin *et al.* 2010).

Confirmed records of *S. concolor* are restricted to the

Betampona area (Britt 1999, Britt & Virkaitis 2003), Masoala area (Nicoll & Langrand 1989, Schreiber *et al.* 1989, Hawkins *et al.* 2008, Hawkins 2012), Mananara Nord area (Nicoll & Langrand 1989, Schreiber *et al.* 1989), Zahamena area (Hawkins *et al.* 2008), and imprecise localities between Betampona, Zahamena and Masoala (Grandidier & Petit 1932, Albignac 1973; Fig. 1). All observations of *S. concolor* at these sites have been in non-degraded rainforest habitat between 200 and 650 m, and few sightings in the past 15 years have been reported (Hawkins *et al.* 2008, Hawkins 2012). As part of an ongoing study of carnivore ecology in the Makira–Masoala region of northeastern Madagascar, our objective was to assess the presence and relative recording frequency of Brown-tailed Vontsira *Salanoia concolor* within Makira Natural Park, and, if present, to compare its occurrence with that of humans

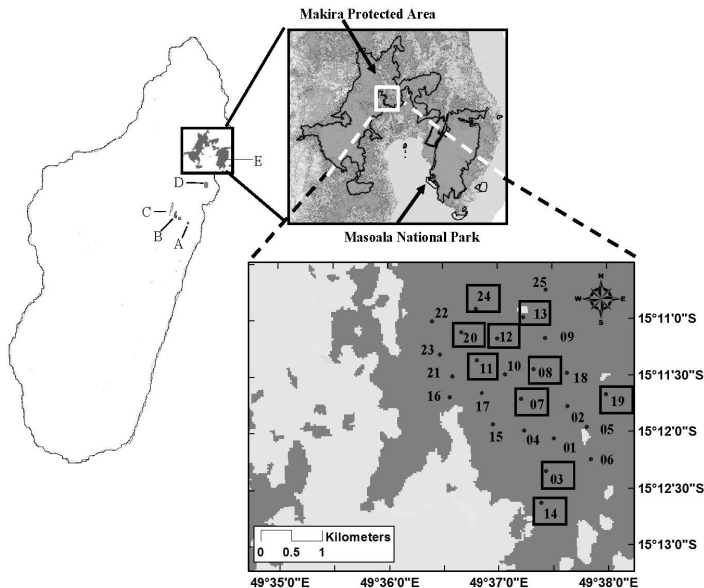


Fig. 1. Madagascar, showing locations of all known documented records of Brown-tailed Vontsira *Salanoia concolor* (A, B, D, E) and Durrell's Vontsira *S. durrelli* (C), and successive insets showing location of the Anjanaharibe study site, and the location of each camera-station (stations 1–20, 2008 and 1–25, 2010). Camera-stations were located inside rainforest habitat (dark grey) with no stations in the degraded/matrix forest (light grey). Boxed locations recorded *S. concolor*. A, Betampona Special Reserve; B, Zahamena National Park; C, Lac Alaotra area; D, Mananara Nord National Park; E, Masoala National Park.

and with those of other carnivores, native and introduced. We predicted there would be avoidance between *S. concolor* and human (non-researcher), introduced domestic cat and/or its wild progenitor *Felis catus* and/or *F. silvestris* (hereafter, 'cat'), domestic dog *Canis familiaris* and Small Indian Civet *Viverricula indica*, based on previous studies of Madagascar's endemic carnivores in Ranomafana National Park (Gerber *et al.* 2010, 2012a).

Study site and methods

Makira Natural Park, a 372,470 ha natural park and 351,037 ha community-managed buffer zone, is the largest protected area in Madagascar and holds the largest remaining contiguous rainforest on the island (Kremen 2003, WCS 2004). Makira Natural Park covers an elevation range from 300 to 1,447 m, incorporates lowland and mid-altitude rainforest, and is believed to contain the highest species richness (all biota combined) in all of Madagascar (Holmes 2007).

We established a camera-trapping grid (centred on 15°11'40"S, 49°37'13"E) within the Anjanaharibe region of the Makira Natural Park from 7 September to 13 November 2008 and from 18 September to 17 November 2010. Despite the social and political turmoil in the country during this time, habitat and landscape conditions did not change at this site. The study site was located, at its closest point, 2.75 km north-east of the village of Andaparaty and 2.60 km south-east of the village of Sahantaha (Fig. 1) and elevation, recorded using a handheld GPS unit (Garmin 60CSx), ranged from 350 to 690 m. We used both digital (Moultrie D40, Reconyx PC85 and Cuddeback IR) and film-loaded camera-traps (DeerCam DC300) in

a grid-like pattern across the landscape to sample carnivores photographically. The 2008 survey consisted of 20 camera-stations and the 2010 survey of 20 stations in the same locations plus an additional five stations (Fig. 1). Camera-stations were spaced 400–600 m apart. Each camera-station held two cameras, operational 24 hr/day, positioned about 20–30 cm off the ground, and placed on opposing sides of existing human trails (0.5–1.0 m wide) and game trails to photograph passing wildlife. We checked cameras every 5–10 days to change batteries and memory cards, and used neither bait nor lure.

We define a 'photographic event' as any point at which an animal triggers the camera (either by movement or body heat), thus providing one to three photographs (depending on camera model) of this individual. We define a 'capture' as one or more photographic events of a given species, at a particular camera-station, that are separated from each other by less than 30 minutes, i.e. the capture lasts a variable period of time and ends when there is a gap of at least 30 minutes before the next photographic event of that species at that camera. Thus, where a duo of the same species was photographed simultaneously, these occurrences constitute a single 'capture' of this species, to reduce problems of non-independence of events. To provide a measure of relative frequency of encounter for each species, we calculated 'trap success' by dividing the number of captures by the total number of trap-nights multiplied by 100 (a trap-night is a 24-hr period during which at least one of two cameras at a particular station was functioning). To examine species associations that might influence *S. concolor* presence we plotted capture locations (each camera-station) for *S. concolor* and introduced carnivores for each year. Finally, our team's continued surveys across the Makira region gave further information on *S. concolor*.

Results

During the two surveys (2008, 2010) we captured six endemic carnivore species (Fosa or Fossa *Cryptoprocta ferox*, Fanaloka or Malagasy Civet *Fossa fossana*, Falanouc or Malagasy Small-toothed Civet *Eupleres goudotii*, Ring-tailed Vontsira or Ring-tailed Mongoose *Galidia elegans*, Broad-striped Vontsira or Broad-striped Mongoose *Galidictis fasciata* and *S. concolor*) and three species of introduced (exotic) carnivores (cat, dog and Small Indian Civet; Table 1). The captures of *S. concolor* (Fig. 2) are the first records within the Makira Natural Park. The recorded elevation range for *S. concolor* captures was 404–680 m. *Salanoia concolor* was captured at more stations in the first survey (2008: 10 captures at eight stations) than in the second survey (2010: four at four stations; Table 1). *Salanoia concolor* was captured both apparently singly ($n = 8$ captures) and in apparent duos ($n = 6$ captures) and all captures occurred during daylight, between 05h45 and 17h00. Station 14 was the camera-station nearest to a village (1.75 km) and nearest the forest edge (0.09 km; Fig. 1) to capture the species; no humans were captured there. Additionally, *S. concolor* was not captured at camera-stations with high human trap success or high introduced carnivore trap success (e.g. station 15, where human trap success = 26.2).

We observed minimal co-occurrence between *S. concolor* and domestic dogs, with overlap at only one station in 2008 and none in 2010 (Fig. 3). Only five (19%) of the dog captures



Fig. 2. Brown-tailed Vontsira *Salanoia concolor*, Makira Natural Park, Madagascar, 6 October 2008.

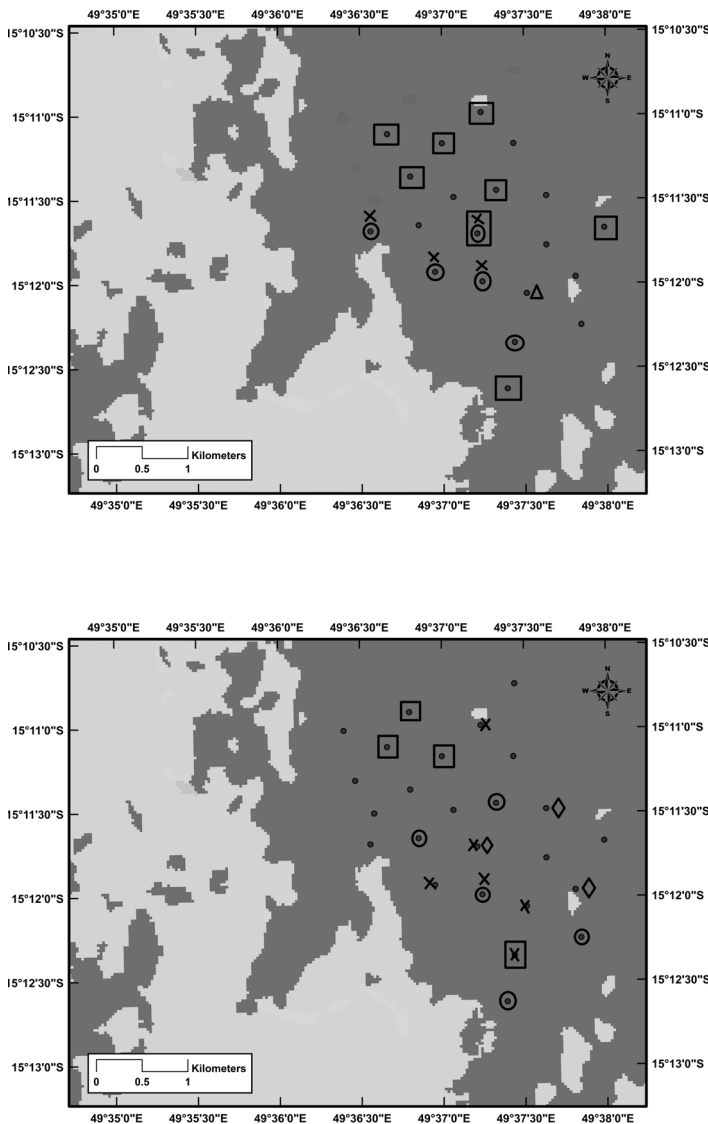


Fig. 3. Distribution of Brown-tailed Vontsira *Salanoia concolor* (□), human (non-researchers) (x), domestic dog (○), introduced cat (◇) and Small Indian Civet *Viverricula indica* (Δ) across the 20-camera-station 2008 survey (A) and the 25-camera-station 2010 survey (B) in the Anjanaharibe study site, Makira Natural Park, Madagascar.

across the two surveys occurred simultaneously (same day and time) with human captures. All these simultaneous captures were located at one station, station 15, during the 2008 survey. Co-occurrence with *S. concolor* and humans (non-researchers) was also minimal: at only one station in 2008 (station 07) and one station in 2010 (station 03). In addition, we did not observe overlap or co-occurrence of *S. concolor* with introduced cats or Small Indian Civets, although these latter two species were found at few stations (Fig. 3). Compared with 2008, in 2010 humans, dogs and cats seemed more widespread, including, apparently, increased presence within core forest (Fig. 3; Table 1); Small Indian Civet was not recorded in the second year.

Additional surveys across the Makira Natural Park (January–March 2011) photographed *S. concolor* 19 km south-east of the Anjanaharibe forest site, four times (Fig. 4), just outside the park in highly degraded forest by a camera-grid centred on 15°16'52"S, 49°46'04"E, about 2.0 km from the village of Sahavary and Andongana at recorded elevations of 292–399 m.

Discussion

This is the first confirmation of *Salanoia concolor* in the Makira Natural Park, expanding its known range 60–70 km northwards and westwards. To clarify the range of *S. concolor* and connectivity of its populations throughout this region, more surveys are needed across mid- and low-elevation forests throughout the Makira Natural Park.

Hawkins *et al.* (2008) reported that known records for *S. concolor* range in elevation from 200 to 650 m and that significant survey effort in eastern rainforest in recent years in areas above 600 m captured no *S. concolor*; however, the amount of that survey effort in this period that was expended within the species's small known geographic range is not readily available. A capture at 680 m at station 13 is the first *S. concolor* record above 650 m. Station 13 was the highest in the entire camera-grid, so this carnivore may occur in this area even above 680 m. There have been few records of *S. concolor* in the last 15 years (Hawkins *et al.* 2008, Hawkins 2012); the species may be rare and additional research could improve efforts to protect it.

Hawkins *et al.* (2008) reported that *S. concolor* is highly sensitive to human presence and disturbance. Captures from these surveys suggest species avoidance between *S. concolor* and humans. Closer investigation revealed that 67% of all humans photographed ($n = 99$ individuals; 34% of independent human captures) occurred at one camera-station (station 15) on the forest edge, within 2 km of the village of Andaparaty (Fig. 1). No *S. concolor* captures occurred at this particular camera-station during the two survey periods, suggesting that this species avoids areas with human presence. Of the 25 total camera-stations (combining 2008 and 2010), two captured both *S. concolor* and humans (though not at same time or day), whereas eight had *S. concolor* only and six had humans only (Fig. 3).

Salanoia concolor and Madagascar's co-occurring endemic carnivores are negatively affected by the presence of introduced carnivores, particularly in fragmented and degraded habitat (Farris & Kelly 2011, Gerber 2012a, 2012b). For example, in Ranomafana National Park in southeast Madagascar introduced carnivore capture rates are higher in fragmented and degraded forests, and cat capture rates have a strong

Table 1. Number of photographic captures and the trap success (TS) for carnivore species, introduced species and humans in the Anjanaharibe region of the Makira Natural Park, Madagascar, in 2008 and 2010.

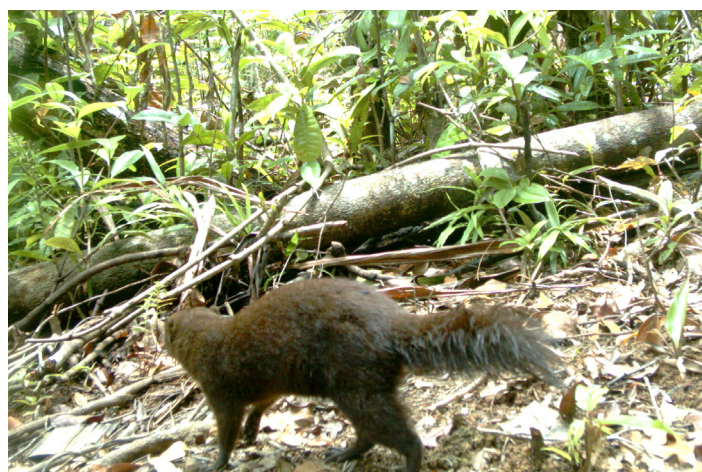
Category	English name	Scientific name	2008	2008	2010	2010
			# Captures ^a	TS ^b (± SE)	# Captures ^a	TS ^b (± SE)
Endemic carnivores			322	24.3 (± 2.3)	246	19.4 (± 2.3)
	Brown-tailed Vontsira	<i>Salanoia concolor</i>	10	0.8 (± 0.2)	4	0.6 (± 0.4)
	Broad-striped Vontsira	<i>Galidictis fasciata</i>	31	2.4 (± 0.7)	11	1.1 (± 0.5)
	Ring-tailed Vontsira	<i>Galidia elegans</i>	16	1.2 (± 0.3)	16	1.2 (± 0.3)
	Falanouc	<i>Eupleres goudotii</i>	41	3.1 (± 0.8)	27	2.1 (± 0.7)
	Fanaloka	<i>Fossa fossana</i>	184	13.9 (± 3.0)	162	12.2 (± 2.3)
	Fosa	<i>Cryptoprocta ferax</i>	40	3.0 (± 0.9)	26	2.2 (± 0.7)
Introduced carnivores			21	1.6 (± 0.7)	11	1.1 (± 0.5)
	Small Indian Civet	<i>Viverricula indica</i>	2	0.1 (± 0.1)	0	0.0 (± 0.0)
	Domestic dog	<i>Canis familiaris</i>	19	1.4 (± 0.7)	8	0.9 (± 0.5)
	Cat (domestic, feral or wild progenitor)	<i>Felis silvestris</i> and/or <i>F. catus</i>	0	0.0 (± 0.0)	3	0.2 (± 0.1)
Bush Pig			1	0.1 (± 0.1)	2	0.1 (± 0.1)
Humans (Malagasy villagers)			28	2.1 (± 1.2)	22	1.5 (± 0.6)

^a # Captures = the number of captures. A 'capture' comprises all photographic events of a given species, at a particular camera-station, that are separated by less than 30 minutes from the next photographic event at that station of that species.

^b TS = trap success: the number of captures / the number of trap-nights × 100, with standard error (± SE). Total trap-nights for Anjanaharibe in 2008 (from 20 camera-stations) was 1,315 and for Anjanaharibe in 2010 was 1,230 (from 25 camera-stations).



Fig. 4. Brown-tailed Vontsira *Salanoia concolor* just outside the Makira Natural Park, near the village of Sahavary. (Left) a duo in highly degraded forest, 17 January 2011; (right) a single in highly degraded forest on 19 January 2011.



negative relationship with *G. elegans* occupancy (Gerber *et al.* 2010, 2011, 2012a, 2012b). Additional camera-trapping surveys in Makira also showed higher introduced carnivore and human capture rates in fragmented and degraded forests, and negative correlations between endemic carnivore and human capture rates, as well as between endemic carnivore and introduced carnivore capture rates (Farris & Kelly 2011). The records near Sahavary and Andongana indicate, however, that *S. concolor* can sometimes occupy human-altered forest habitat. The apparent negative relationships between *S. concolor* and dogs, cats and humans give serious concerns about long-term protection and management of this species within a human-altered landscape in which human-wildlife conflicts are mounting. Managers should consider the implementation of a trapping and removal programme for cats and dogs throughout these forest sites.

At the Anjanaharibe study site, *S. concolor* was captured at eight stations during the 2008 survey but only four during the 2010 survey. Additionally, trap success decreased by 0.13 from 2008 to 2010. These negative changes highlight the need for additional research that investigates how human encroachment and introduced carnivores impact *S. concolor* populations. In the later survey human captures were more widespread across the study site, and illegal mammal traps (noose traps) had been erected within the grid. Poaching occurs at this site (Golden 2009; C. Golden verbally 2012), although its rate is unknown. In addition, during this period introduced cat and Bush Pig *Potamochoerus larvatus* captures increased (see Table 1). These differences (including more widespread distributions across the grid) may represent sustained increases in human, cat and Bush Pig numbers that might impact wildlife trap success across this study site. We are conducting additional surveys at the Anjanaharibe study site and throughout the Makira Natural Park to investigate *S. concolor* and co-occurring carnivores and to determine the impacts of these invasive pressures on *S. concolor* distribution and trapping rates. Understanding

how human encroachment, poaching and forest degradation affect *S. concolor* is also vital for this species's long-term protection. Its apparent reliance on lowland rainforest makes it particularly vulnerable to on-going fragmentation across its restricted range (see Sussman *et al.* 1994).

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