Assessment of ring-tailed lemur *Lemur catta* populations in south-western Madagascar

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SUPPLEMENTARY MATERIAL 1 Expanded details of Methods.

Lemur catta are known to occur in a wide range of ecosystems (Goodman et al., 2006), therefore, our surveys incorporated multiple habitats (Supplemental Table 1).

Line Transect methods From June – July 2019, we conducted rapid assessment surveys at five locations with historic presence of *L. catta*: 1) Fiherenana forest, 2) Ranomay forest, 3) Zombitse forest, 4) Vohibasia forest, and 5) two circuits in Isalo National Park – Namaza Circuit and Piscine Naturelle. Each site was surveyed for a minimum of five days, except Isalo National Park which was surveyed for four days (mean = 5.5 ± 1.3, range = 4 – 7 days). Survey duration was determined by whether and when animals were detected. Typically, animals were detected within the first two days of surveys, and continued for at least another 3 – 5 days to allow sufficient time for population counts. If, however, animals had not been detected via sightings or traces (e.g., feces, tracks) by the fifth day of surveys, we moved on to the next survey site.

During these surveys, four observers walked trails at a constant rate (approximately 1 km/hr) stopping frequently to look and listen for *L. catta*. Trails were chosen based on the advice of local guides to maximize our chances of detecting animals. We surveyed six trails at Fiherenana; seven trails at Ranomay; five trails apiece at Zombitse and Vohibasia; and four trails at Isalo. We covered roughly the same distance at each site (mean = 15.44 km ± 2.0 km). Because *L. catta* are known to exhibit increased feeding and foraging activity in the mornings, followed by long periods of rest during the hottest parts of the afternoon (Ellwanger & Gould, 2011; Rea et al., 2014; Bray et al., 2017), we restricted our surveys to between 07:00 – 13:00, as animals were easiest to detect when they were active during the morning hours.

Upon detection, we noted the time and method of detection (visual, vocal, other), GPS location of the area where animals were first observed, and group size, when possible. We then remained with the group at a minimum distance of 10 m until we were able to more confidently record group size and demographics, such as sex and age. Group sizes ranged from 2 to 16 individuals (mean = 8.64 ind./group +/- 4.41 sd); we never recounted groups with the same size and/or demographic composition during surveys within any of our sites. This allowed us to easily distinguish among groups and avoid recounting individuals during subsequent surveys.

Broad Survey Methods We surveyed an additional 78 sites across seven fokontany throughout the Mahafaly Plateau. Previous survey efforts of the Mahafaly Plateau were noted as being insufficient, with only 11 groups (80-100 individuals total) reported from surveys in Tsimanampesotse National Park between 2006-2014 (Sauther et al., 2013; Gould and Sauther, 2016; LaFleur et al., 2016). Our surveys were conducted during two-week intervals during June,

August, September, and October 2018 and March, April, and August 2019. Due to the vast areas that fokontany cover, residents were uncertain of the boundaries. Thus, fokontany assignments were self-reported by residents, but may conflict with official fokontany circumscriptions. Local guides familiar with the *L. catta* groups in the area were consulted and guided teams to known sleeping sites for each group. Each sleeping site was considered discrete from others in the area; thus, a survey location can contain multiple sleeping sites in close proximity (e.g., three sites in the case of Befarafatsy; see Supplementary Table 1 and Figure 1). Enumeration of *L. catta* was only conducted once for each sleeping site and visits to sleeping sites were not repeated.

Since sites surveyed around the Mahafaly Plateau lack the infrastructure for conducting line transect sampling, we used the "broad survey method" to count individuals at sleeping sites (NRC, 1981; Sussman and Phillips-Conroy, 1995; Sussman et al., 2003). Broad survey methods are a time and cost-efficient technique used to assess population presence and relative numbers along trails and river (Sussman and Phillips-Conroy, 1995; Sussman et al., 2003).

Specifically, our survey methods were as follows:

1) Surveys were carried out by Randrianjaka, Randriamampionona, and Rakotoniaina. Researchers drove to several villages in a fokontany and inquired with residents about the presence of *L. catta*. Whenever a village confirmed the presence of nearby *L. catta*, we established a base camp there and a local guide was hired to lead the team to sleeping sites where GPS coordinates were recorded.
2) We spent no more than three and a half hours at any single sleeping site. When sleeping sites were nearby, surveys began at 05:00 and continued until all individuals had left their sleeping site for the day, which was never later than 08:30. In the event a survey location was particularly far away from the base camp, surveys were conducted in the evening, after lemurs had returned to their sleeping site, between 16:30 and 20:00. If a survey location had multiple sleeping sites (e.g., Befarafatsy, Mananiho, and Emaky), sleeping sites were surveyed on different days.
3) During surveys, we recorded group demography, i.e., number of males/females and adults/juveniles, at each sleeping site. This information was used to distinguish groups from those at nearby sleeping sites, thereby minimizing the potential for recournting individuals in subsequent surveys. If individuals became active and left their sleeping site prior to our arrival, we did not count members of that group, instead heading to a new location for the next survey. Thus, some site counts may be under-representative of the actual population size.
4) In the event that more than one group occupied the same sleeping site during our survey, we counted only stationary individuals within each group. Aggregations of individuals were identified as belonging to different groups if they were separated by at least 200 m. To determine the number of individuals within each group, we approximated a central point from which the majority of individuals were within one meter. From that central point, we expanded our count of the group members to incorporate all individuals within a 25 m radius. Individuals that could not confidently assigned group membership were excluded from population counts.

We acknowledge that rapid surveys come with an inherent risk of recounting individuals and used multiple techniques to minimize this occurrence. Again, we relied on group size and composition to distinguish groups from those at nearby sleeping sites to avoid recounts. We also erred ont eh side of caution to avoid inflating group sizes by excluding individuals that could not be confidently assigned to a specific group. Additionally, we acknowledge that local guides are the most knowledgeable about the location and distribution of *L. catta*; thus, we relied on their experience to guide us to sleeping sites where we could identify unique groups and minimize likelihood of recounting individuals. Nevertheless, to account for the potential replication, we provide both a minimum number of *L. catta* present by only considering the largest group size at locations where multiple groups were identified, and estimated population counts by summing group sizes for all groups encountered at each sampling location.

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SUPPLEMENTARY TABLE 1 Site names, locations, protected status, and number of groups and number of individuals per site surveyed for presence of *Lemur catta* from 2018-2019 in Madagascar. Fokontany are government recognized administrative units comprised of one or more villages. Fokontany names were only provided for locations within the Mahafaly Plateau. Locations with 'unk' listed for number of groups and individuals indicates sites where *L. catta* were present but accurate counts were not possible. [1] indicates a site previously surveyed by Hawkins, 1999; [2] indicates a site previously surveyed by Siers, 2007; [3] indicates a site previously surveyed by Gardner et al., 2009; [4] indicates a site previously surveyed by Kasola et al., 2020. [a] indicates a site previously identified as likely extirpated by Gould & Sauther, 2016 and LaFleur et al., 2016.

Site number	Fokontany	Site name	Latitude	Longitude	Protected Status	Habitat Type	N groups	N individuals	Max Group Size
1	-	Isalo[1]	22°28'11.8"S	45°15'38.3"E	National Park	Spiny Forest	2	23	14
2	-	Zombitse[2,a]	22°45'0.0"S	44°37'0.0"E	National Park	Succulent Woodland/ Dry Forest	0	0	0
3	-	Vohibasia[3,a]	22°42'0.0"S	44°49'0.0"E	National Park	Gallery Forest	2	10	8
4	-	Fiherenana[3,a]	23°14'0.0"S	43°52'0.0"E	Non-protected	Spiny Forest	5	40	14
5	-	Ranomay	23°34'28.7"S	44°19'41.5"E	Non-protected	Spiny Forest	9	84	16
6	Ankaranila	Ankamena	23°43'08.1"S	43°43'30.6"E	Non-protected	Spiny Forest	unk	unk	unk
7	Ankaranila	Antsono	23°42'19.8"S	43°43'34.1"E	Non-protected	Spiny Forest	unk	unk	unk
8	Ankaranila	Befarafatsy site 1	23°44'09.3"S	43°42'14.4"E	Non-protected	Spiny Forest	1	19	19
9	Ankaranila	Befarafatsy site 2	23°44'39.9"S	43°42'11.2"E	Non-protected	Spiny Forest	1	4	4
10	Ankaranila	Befarafatsy site 3	23°44'47.3"S	43°42'07.8"E	Non-protected	Spiny Forest	1	8	8
11	Efoetse	Ambondrondremonja	24°03'33.0"S	43°45'09.7"E	National Park	Spiny Forest	1	10	10
12	Efoetse	Andramaniloke	24°03'15.8"S	43°45'43.2"E	National Park	Spiny Forest	unk	unk	unk
13	Efoetse	Andranoilovy[4]	24°02'43.8"S	43°45'15.1"E	National Park	Spiny Forest	1	19	19
14	Efoetse	Andranonaomby	24°05''54.8"S	43°45'30.9"E	National Park	Spiny Forest	1	19	19
15	Efoetse	Andranovao – South[4]	24°01'48.7"S	43°44'39.9"E	National Park	Spiny Forest	1	22	22
16	Efoetse	Andranovao – East	24°01'10.8"S	43°44'28.6"E	National Park	Spiny Forest	1	7	7
17	Efoetse	Andranovao – North	24°01'06.2"S	43°45'28.1"E	National Park	Spiny Forest	1	4	4
18	Efoetse	Emande	24°05'26.9"S	43°45'22.5"E	National Park	Spiny Forest	1	12	12
19	Efoetse	Grotte Maiky[4]	24°02'58.9"S	43°45'28.5"E	National Park	Spiny Forest	1	18	18
20	Efoetse	Vintany[4]	24°02'37.8"S	43°45'19.5"E	National Park	Spiny Forest	1	24	24
21	Manasy	Anaviavy	24°11'42.2"S	43°47'05.4"E	National Park	Spiny Forest	1	3	3
22	Manasy	Sadro	24°10'35.1"S	43°46'13.2"E	National Park	Spiny Forest	1	18	18

Site number	Fokontany	Site name	Latitude	Longitude	Protected Status	Habitat Type	N groups	N individuals	Max Group Size
23	Manasy	Tsifeleha	24°10’13.5”S	43°46’07.5”E	National Park	Spiny Forest	1	17	17
24	Manasy	Vohindambo	24°12’46.0”S	43°47’23.5”E	National Park	Spiny Forest	unk	unk	unk
25	Manasy	Vohombohitse	24°11’07.0”S	43°45’59.2”E	National Park	Spiny Forest	1	15	15
26	Manasy	Vohombohitse – East	24°11’07.0”S	43°45’59.2”E	National Park	Spiny Forest	1	13	13
27	Ekoritsike (Malangiriake)	Andramanoabe	24°34’34.7”S	43°57’59.5”E	National Park	Spiny Forest	1	13	13
28	Ekoritsike (Malangiriake)	Andramanoamasay	24°34’54.3”S	43°57’57.3”E	National Park	Spiny Forest	1	18	18
29	Itampolo	Ambaro	24°38’39.4”S	43°59’27.2”E	Non-protected	Spiny Forest	3	30	14
30	Itampolo	Amborombe	24°37’42.7”S	43°58’56.6”E	Non-protected	Spiny Forest	1	7	7
31	Itampolo	Androimpano	24°39’00.8”S	43°57’47.0”E	Non-protected	Spiny Forest	1	7	7
32	Itampolo	Ankoramena	24°36’17.6”S	43°56’39.4”E	Non-protected	Spiny Forest	4	62	17
33	Itampolo	Ankorandrebale	24°37’02.8”S	43°57’57.9”E	Non-protected	Spiny Forest	3	38	15
34	Itampolo	Begodara	24°39’39.2”S	43°59’21.3”E	Non-protected	Spiny Forest	1	16	16
35	Itampolo	Evohimena	24°37’01.6”S	43°56’50.0”E	Non-protected	Spiny Forest	1	10	10
36	Itampolo	Hily	24°38’09.6”S	43°59’37.0”E	Non-protected	Spiny Forest	1	12	12
37	Itampolo	Marohazo	24°39’36.0”S	43°58’18.5”E	Non-protected	Spiny Forest	unk	unk	unk
38	Itampolo	Nikotse	24°38’18.6”S	43°56’56.8”E	Non-protected	Spiny Forest	1	6	6
39	Itampolo	Ranofoty	24°35’42.9”S	43°57’56.3”E	National Park	Spiny Forest	2	24	19
40	Ambaromionga	Ambalalava	24°30’46.7”S	44°24’59.5”E	Non-protected	Gallery Forest	1	17	17
41	Ambaromionga	Ambatsiake	24°31’17.7”S	44°24’51.7”E	Non-protected	Gallery Forest	0	0	0
42	Ambaromionga	Ampatifaty	24°31’00.0”S	44°25’28.7”E	Non-protected	Gallery Forest	0	0	0
43	Ambaromionga	Ampatifaty – South	24°31’03.6”S	44°25’27.8”E	Non-protected	Gallery Forest	1	6	6
44	Ambaromionga	Andemaky	24°30’45.1”S	44°25’29.2”E	Non-protected	Gallery Forest	2	11	7
45	Ambaromionga	Ankoiake	24°31’35.7”S	44°25’13.5”E	Non-protected	Gallery Forest	1	4	4
46	Ambaromionga	Antanifoty	24°31’26.6”S	44°24’12.2”E	Non-protected	Gallery Forest	0	0	0
47	Ambaromionga	Baibozovelo	24°30’53.2”S	44°24’53.2”E	Non-protected	Gallery Forest	1	11	11
48	Ambaromionga	Bemananga	24°31’26.1”S	44°25’38.4”E	Non-protected	Gallery Forest	6	55	17
49	Ambaromionga	Eandrotse	24°31’28.5”S	44°24’19.2”E	Non-protected	Gallery Forest	1	9	9
50	Ambaromionga	Efiay	24°30’56.4”S	44°24’48.3”E	Non-protected	Gallery Forest	2	41	23
51	Ambaromionga	Efisake	24°30’44.7”S	44°24’51.9”E	Non-protected	Gallery Forest	1	21	21

Site number	Fokontany	Site name	Latitude	Longitude	Protected Status	Habitat Type	N groups	N individuals	Max Group Size
52	Ambaromionga	Emanga	24°32’18.0”S	44°23’40.4”E	Non-protected	Gallery Forest	1	21	21
53	Ambaromionga	Farampo	24°31’48.8”S	44°24’43.3”E	Non-protected	Gallery Forest	3	32	11
54	Ambaromionga	Jamia	24°30’33.8”S	44°24’30.0”E	Non-protected	Gallery Forest	2	20	12
55	Ambaromionga	Kilibemizaravoatse	24°30’57.8”S	44°25’21.2”E	Non-protected	Gallery Forest	0	0	0
56	Ambaromionga	Lavoila	24°30’53.9”S	44°25’28.0”E	Non-protected	Gallery Forest	0	0	0
57	Ambaromionga	Lovokarivo	24°31’25.9”S	44°23’59.9”E	Non-protected	Gallery Forest	0	0	0
58	Ambaromionga	Mananiho site 1	24°30’52.4”S	44°25’53.9”E	Non-protected	Gallery Forest	4	46	15
59	Ambaromionga	Mananiho site 2	24°31’06.5”S	44°25’41.2”E	Non-protected	Gallery Forest	1	7	7
60	Ambaromionga	Marohazo	24°31’26.0”S	44°24’19.5”E	Non-protected	Gallery Forest	0	0	0
61	Ambaromionga	Marovahy	24°31’58.0”S	44°25’24.1”E	Non-protected	Gallery Forest	1	9	9
62	Ambaromionga	Misigada	24°31’43.7”S	44°25’11.3”E	Non-protected	Gallery Forest	2	15	10
63	Ambaromionga	Niteraha	24°30’40.9”S	44°25’40.4”E	Non-protected	Gallery Forest	2	38	20
64	Ambaromionga	Tainakoho	24°30’54.5”S	44°25’15.5”E	Non-protected	Gallery Forest	0	0	0
65	Ambaromionga	Telomaly	24°32’03.3”S	44°24’54.3”E	Non-protected	Gallery Forest	3	63	32
66	Ambaromionga	Vohibato	24°30’38.4”S	44°25’05.2”E	Non-protected	Gallery Forest	3	48	18
67	Sakoantovo	Agnadabodo	24°30’24.2”S	44°26’08.4”E	Non-protected	Gallery Forest	1	8	8
68	Sakoantovo	Anaviavibe	24°30’44.9”S	44°26’57.7”E	Non-protected	Gallery Forest	0	0	0
69	Sakoantovo	Anjamampaly	24°29’58.4”S	44°26’18.3”E	Non-protected	Gallery Forest	3	35	14
70	Sakoantovo	Ankalimboronabo	24°30’45.0”S	44°26’43.7”E	Non-protected	Gallery Forest	2	22	12
71	Sakoantovo	Antanimena	24°31’41.9”S	44°26’14.5”E	Non-protected	Gallery Forest	0	0	0
72	Sakoantovo	Antranompoly	24°31’30.8”S	44°26’25.3”E	Non-protected	Gallery Forest	1	12	12
73	Sakoantovo	Beara	24°30’21.1”S	44°26’06.2”E	Non-protected	Gallery Forest	0	0	0
74	Sakoantovo	Berovantsy	24°30’56.1”S	44°26’07.4”E	Non-protected	Gallery Forest	0	0	0
75	Sakoantovo	Betsifa	24°30’15.8”S	44°25’37.1”E	Non-protected	Gallery Forest	1	9	9
76	Sakoantovo	Ekandatse	24°30’17.7”S	44°25’56.3”E	Non-protected	Gallery Forest	0	0	0
77	Sakoantovo	Emaky site 1	24°30’12.9”S	44°25’47.9”E	Non-protected	Gallery Forest	1	12	12
78	Sakoantovo	Emaky site 2	24°30’17.8”S	44°26’02.7”E	Non-protected	Gallery Forest	0	0	0
79	Sakoantovo	Sakoamahity	24°31’14.3”S	44°26’33.6”E	Non-protected	Gallery Forest	0	0	0
80	Sakoantovo	Sakoantovo	24°24’46.8”S	44°26’55.2”E	Non-protected	Gallery Forest	1	7	7
81	Sakoantovo	Sambitehaky	24°30’59.9”S	44°26’20.6”E	Non-protected	Gallery Forest	1	10	10

Site number	Fokontany	Site name	Latitude	Longitude	Protected Status	Habitat Type	N groups	N individuals	Max Group Size
82	Sakoantovo	Tognidrianafo	24°30’22.4”S	44°26’19.5”E	Non-protected	Gallery Forest	0	0	0
83	Sakoantovo	Vohibondro	24°29’37.6”S	44°26’26.6”E	Non-protected	Gallery Forest	0	0	0