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Ring-Tailed Lemur *(Lemur catta)* Health Parameters across Two Habitats with Varied Levels of Human Disturbance at the Bezà Mahafaly Special Reserve, Madagascar

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Key Words

Anthropogenic change · Conservation biology · Hematology · Blood biochemistry · Habitat degradation · Dehydration

Abstract

The health of 36 wild, free-ranging ring-tailed lemurs *(Lemur catta)* at the Bezà Mahafaly Special Reserve was assessed across 2 habitats of varied human impact: a reserve riverine gallery forest, and a degraded mixed dry deciduous and *Alluaudia*-dominated spiny forest. While there were no statistically significant differences in leukocyte count or differential between habitats, female lemurs in the reserve gallery forest had significantly higher percentages of monocytes and eosinophils than male lemurs in the gallery forest. Lemurs from the degraded spiny habitat had significantly higher mean packed cell volume, hematocrit, hemoglobin, total protein, blood urea nitrogen, chloride, ionized calcium and urine specific gravity than lemurs from the reserve gallery forest. These findings may reflect lower hydration levels in lemurs living in degraded habitat, providing evidence that environmental degradation has identifiable impacts on the physiology and health of wild, free-ranging ring-tailed lemurs living in nearby habitats. Given the greater evidence of human impact in the mixed dry deciduous/spiny forest habitat, a pattern seen throughout southern Madagascar, biomedical markers suggestive of decreased hydration can provide empirical data to inform new conservation policies facilitating the long-term survival of this lemur community.

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Introduction

The lemurs of Madagascar face probable extinction within the next half-century if adequate conservation programs are not developed [Sauther et al., 2013; Schwitzer et al., 2014]. Habitat degradation and loss remain the major threat to primate survival, with Madagascar being one of the top 8 hotspots in terms of biodiversity and ongoing habitat loss, and the endemic lemurs being the most endangered primate taxa [Schwitzer et al., 2014]. Given the threat to lemurs in the wild, it is essential to determine how human-induced habitat change is affecting their health. While numerous studies have evaluated the health of wild, free-ranging lemur species, as well as the effect of habitat fragmentation and disturbance on primate populations in Madagascar [Dutton et al., 2003; Junge and Louis, 2005; Sauther et al., 2006; Miller et al., 2007; Dutton et al., 2008; Junge et al., 2008; Irwin et al., 2010], the effect of varying levels of anthropogenic disturbance on lemur health remains largely unknown. Since 2003, the ring-tailed lemurs *(Lemur catta)* at the Bezà Mahafaly Special Reserve (BMSR) have been the focus of an intensive study to assess the effects of anthropogenic and climate factors on behavior, ecology, genetics and health [Sauther et al., 2006; Miller et al., 2007; Parga et al., 2012]. An initial biomedical evaluation of this population focused on 3 microhabitats within the gallery forest region of BMSR that varied in terms of human impact [Miller et al., 2007]. In contrast, this study compares the biomedical values of BMSR gallery forest lemurs living in a gallery reserve habitat with a lemur population inhabiting a mixed dry deciduous and *Alluaudia*-dominated spiny forest that has been substantially altered by anthropogenic disturbance. The goal is to determine if there are biomedical indicators of lower hydration and higher levels of stress or inflammation in lemurs living in the more degraded habitat. Given the greater human impact in the mixed dry and spiny forest habitat, evidence of lower hydration and higher levels of stress or inflammation would provide empirical data to inform new conservation policies facilitating the long-term survival of this lemur community, and would be applicable to assess lemur health throughout southern Madagascar.

Materials and Methods

Health evaluation of individual ring-tailed lemurs required direct animal contact to perform physical examinations and to collect morphometric data and biomedical samples. All research adhered to strict animal handling protocols and received IACUC approval (University of North Dakota IACUC Protocol No. 0802-2 and animal assurance No. A3917-01) as well as being permitted by the Convention on International Trade in Endangered Species (CITES Madagascar: 531C-EA10/MG10; CITES USA: 11US040035/9) and Madagascar National Parks (086/12/MEF/SG/DGF/DCB.SAP/SCB).

Study Site and Species

BMSR is located in southwestern Madagascar (23°30′ S, 44°40′ E) and has been the focus of socioecological studies of ring-tailed lemurs since 1987 [Sauther et al., 1999; Sussman et al., 2012]. This study focuses on 2 habitats within BMSR: a reserve riverine gallery forest (Parcel 1, P1) and a degraded mixed dry and spiny forest (Parcel 2, P2). P1 consists of 80 ha of fenced gallery forest, ranging from riverine forest in the eastern part of the parcel, near the seasonal Sakamena River, to drier forest towards the western boundary. It also includes degraded habitat to the south of the fenced portion. P1 is home to 9 troops of ring-tailed lemurs that are habituated to humans and

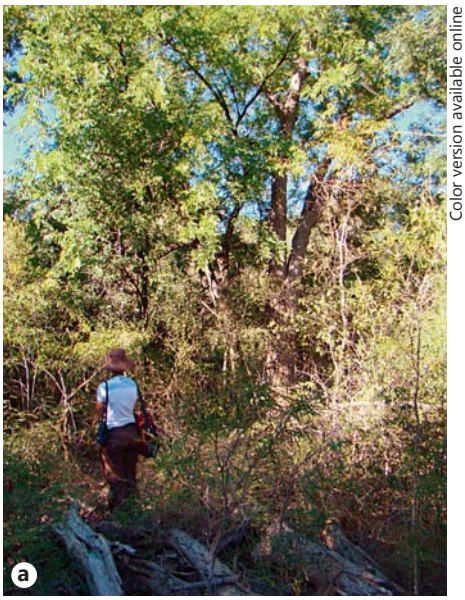

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Fig. 1. P1 (**a**) is the more intact section of the BMSR reserve, P2 (**b**) is the more degraded section.

have been studied intensively for the past decade [Sussman et al., 2012]. The western portion of P1 gradates into P2, which is a 520 ha dry deciduous and *Alluaudia*-dominated spiny forest. Lemurs from this habitat were sampled from troops living within a degraded forest in the north and west portion of P2, near the village of Taolambiby, approximately 6.5 km from the gallery forest. Human impact is greater in P2 than in P1 (fig. 1). Specifically, there is dramatic deforestation and evidence of livestock grazing throughout P2, yet numerous lemur troops live here [Axel and Maurer, 2011]. P2 ring-tailed lemurs have only recently been habituated to humans and thus their health status was previously unknown. Individual lemurs assessed herein did not travel between P1 and P2 during the study period.

Capture and Data Collection

During June 2012, 36 lemurs were captured from P1 (n = 26; 12 males, 14 females) and P2 (n = 10; 6 males, 4 females). Lemurs ranged in age from 4 to >10 years old. All lemurs were adults, with few lemurs <5 years old (P1: n = 3; P2: n = 3). Lemurs were anesthetized using tiletamine/zolazepam (Telazol®, 12–20 mg/kg) administered by blowdart. Anesthesia was maintained using ketamine and/or dexmedetomidine combined with butorphanol administered intramuscularly as needed [Miller et al., 2007; Larsen et al., 2011]. Parameters monitored during anesthesia included anesthetic depth, heart rate, respiratory rate and body temperature. Upon completion of data collection, each lemur received a balanced electrolyte solution subcutaneously (lactated Ringer's solution; 60 ml). Atipamezole (10 mg atipamezole per 1 mg dexmedetomidine) and naloxone (0.02 mg/kg) were administered intramuscularly to reverse the anesthetic effects of dexmedetomidine and butorphanol, respectively. Animals were placed in individual kennels and housed indoors overnight. The following morning, lemurs were released at the site of capture, where they safely returned to their troops and their established social positions.

A complete physical examination, including collection of morphometric measurements and dental impressions, was performed on each lemur. Body weights were taken using a digital hanging scale. Whole blood (1–3 ml) was collected from a femoral vein and placed into separate tubes containing ethylenediaminetetraacetic acid (EDTA) and heparin anticoagulant for hematology and blood biochemistry profiles, respectively. Urine was collected via manual expression of the urinary bladder for urinalysis. Samples were held in the shade at ambient temperature until processed within 8 h of collection. Hematology profiles included a leukogram [total white blood cell (WBC) count and differential WBC count], packed cell volume (PCV) and plasma total protein (TP). A total WBC count was performed manually (Whi-pette®, Exotic Animal Solutions). Blood was placed into hematocrit tubes and spun in a microhematocrit centrifuge at 12,000 rpm for 5 min for determination of PCV and TP. Blood smears were made for later WBC differential count and hemoparasite examination. Blood biochemistry profiles, obtained using a point-of-care analyzer (i-STAT®, Abbott Point of Care Inc.), included sodium, potassium, chloride (Cl^-), ionized calcium (Ca^{2+}), total carbon dioxide (TCO_2), glucose, blood urea nitrogen (BUN), creatinine (Cr), hematocrit (HCT) and hemoglobin (Hb). Urine was evaluated biochemically and microscopically. Urine was placed on a refractometer to determine specific gravity (SG) and on plastic test strips to determine urine biochemistry values (Siemens Multistix® 10 SG, Siemens Healthcare Diagnostics). The remaining urine was centrifuged to separate the liquid from the cellular components (sediment). The sediment was evaluated microscopically.

As the data were not normally distributed, the Wilcoxon signed-rank test was used to analyze data (JMP®11, SAS Institute Inc.) with significance set at $p \leq 0.05$.

Results

All lemurs appeared healthy at the time of evaluation. Several lemurs showed evidence of previous injuries, including torn pinnae, digit deformities, kinked tails, a corneal scar and presumed healed arm fractures. All lemurs had Laelapidae mites. No lemurs had evidence of hemoparasites. There were no sex differences in body weights for either habitat (kg; mean ± SD; P1: females = 2.15 ± 0.14, males = 2.21 ± 0.12, z = 0.85, p = 0.39; P2: females = 2.12 ± 0.23, males = 2.08 ± 0.27, z = 0.53, p = 0.59). There were no habitat differences in body weights either (kg; mean ± SD; P1 = 2.18 ± 0.13, P2 = 2.09 ± 0.24, z = 0.85, p = 0.40).

Hematology and blood biochemistry results are presented in tables 1–3. P2 lemurs had significantly higher mean PCV, TP (table 1), HCT, Hb, BUN, Cl^- and Ca^{2+} and lower TCO_2 than P1 lemurs (table 2). Mean urine SG values (±SD) were significantly higher for P2 lemurs (SG = 1.035 ± 0.033; n = 9) than P1 lemurs (SG = 1.012 ±

Table 1. Hematology values in wild, free-ranging ring-tailed lemurs from reserve and degraded habitats in the BMSR and Tsimanampesotse National Park, Madagascar

Parameter	Intact habitat (P1)			Degraded habitat (P2)			Wilcoxon signed-rank test z, p values	Tsimanampesotse		
	mean ± SD	min. – max.	n	mean ± SD	min. – max.	n		mean ± SD	min. – max.	n
PCV, %	41.2 ± 2.9	34 – 46	26	45.6 ± 3.4	40 – 51	10	3.26, <0.001	38.7 ± 3.6	31 – 45	20
TP, g/dl	6.23 ± 0.38	5.4 – 6.8	26	6.97 ± 0.54	6.2 – 7.8	10	3.31, <0.0009	5.97 ± 0.7	4.2 – 7.2	20
WBC, × 10^3/µl	6,530 ± 1,631	4,180 – 9,075	26	7,315 ± 2,469	4,675 – 12,430	10	0.71, 0.48	4,744 ± 1,129	2,695 – 6,600	20
Neutrophils, × 10^3/µl	1,976 ± 623	861 – 3,426	26	2,563 ± 996	1,478 – 4,269	10	1.13, 0.26	2,330 ± 1,058	1,040 – 4,376	20
Lymphocytes, × 10^3/µl	3,745 ± 1,560	1,619 – 7,395	26	3,767 ± 1,915	2,103 – 7,408	10	0.09, 0.93	1,987 ± 1,079	587 – 3,812	20
Monocytes, 10^3/µl	447 ± 177	167 – 861	26	498 ± 119	305 – 678	10	0.97, 0.33	236 ± 106	86 – 462	20
Eosinophils, × 10^3/µl	356 ± 279	0 – 1,198	26	481 ± 291	0 – 838	10	1.29, 0.20	101 ± 91	0 – 303	19
Basophils, × 10^3/µl	5.8 ± 20.7	0 – 84	26	0.0 ± 0.0	0 – 0	10	0.85, 0.40	13.3 ± 18.3	0 – 55	18
Neutrophils, %	31.5 ± 10.5	12 – 51	26	35.5 ± 9.4	18 – 51	10	1.06, 0.29	49.7 ± 18.3	18 – 77.5	20
Lymphocytes, %	55.6 ± 12.9	32 – 83	26	49.8 ± 9.8	39 – 71	10	1.22, 0.23	41.5 ± 17.9	11 – 70.5	20
Monocytes, %	7.1 ± 3.2	3 – 15	26	7.3 ± 2.2	3 – 9	10	0.94, 0.35	4.9 ± 1.6	2 – 8	20
Eosinophils, %	5.7 ± 4.4	0 – 18	26	6.9 ± 3.9	0 – 12	10	1.13, 0.26	2.4 ± 2.1	0 – 6.5	20
Basophils, %	0.1 ± 0.3	0 – 1	26	0.0 ± 0.0	0 – 0	10	0.85, 0.40	0.3 ± 0.49	0 – 1.5	18

[a] Dutton et al. [2003].

Table 2. Blood biochemistry values in wild, free-ranging ring-tailed lemurs from reserve and degraded habitats in the BMSR and from Tsimanampesotse National Park, Madagascar

Parameter	Intact habitat (P1)			Degraded habitat (P2)			Wilcoxon signed-rank test z, p values	Tsimanampesotse		
	mean ± SD	min. – max.	n	mean ± SD	min. – max.	n		mean ± SD	min. – max.	n
Sodium, mEq/l	143.5 ± 3.2	137 – 150	26	144.2 ± 2.6	141 – 149	10	0.43, 0.67	137 ± 12.7	117 – 156	20
Potassium, mEq/l	3.57 ± 0.50	2.2 – 4.3	26	3.71 ± 0.43	3.0 – 4.5	10	0.46, 0.65	3.99 ± 0.97	2.6 – 5.8	20
Cl, mEq/l	99.8 ± 4.9	89 – 106	26	103.5 ± 3.2	96 – 107	10	2.15, <0.03	99.7 ± 12	79 – 119	20
Ca^{2+}, mmol/l	0.986 ± 0.055	0.88 – 1.07	26	1.056 ± 0.037	1.00 – 1.12	10	3.17, <0.0002	–	–	–
TCO_2, mmol/l	25.7 ± 3.3	19 – 32	25	22.8 ± 3.3	17 – 29	10	2.27, <0.03	–	–	–
Glucose, mg/dl	146 ± 67	38 – 329	26	151 ± 89	44 – 313	10	0.12, 0.90	136 ± 36.9	67 – 211	20
BUN, mg/dl	5.2 ± 4.4	2 – 15	26	8.9 ± 3.2	4 – 14	10	2.60, <0.009	13.3 ± 4.51	5 – 20	20
Cr, mg/dl	0.82 ± 0.10	0.7 – 1.0	26	0.91 ± 0.17	0.6 – 1.2	10	1.73, 0.08	0.88 ± 0.22	0.5 – 1.3	19
HCT, %	35.3 ± 3.0	27 – 42	26	40.6 ± 4.3	35 – 49	10	3.23, <0.001	–	–	–
Hb, g/dl	12.0 ± 1.0	9.2 – 14.3	26	13.8 ± 1.5	11.9 – 16.7	10	3.23, <0.001	–	–	–
Anion gap, mmol/l	22.6 ± 1.3	19 – 25	24	22.5 ± 1.8	20 – 25	10	0.16, 0.88	–	–	–

[a] Dutton et al. [2003].

0.009; n = 19; z = 2.122, $p \leq 0.03$). Sex differences by habitat were found for P1 lemurs for percentages of monocytes and eosinophils (table 3). Sex differences were also found for P1 lemurs for TCO_2 and P2 lemurs for potassium (table 3).

Discussion

Physiological markers of dehydration can include an elevated PCV/HCT, Hb, TP, BUN, Cr, electrolytes and urine SG [George, 2003]. Ring-tailed lemurs in P2 had significantly higher mean PCV, HCT, Hb, TP, BUN, Cl^-, Ca^{2+} and urine SG and a trend toward higher Cr ($p = 0.08$) than P1 lemurs, which strongly supports the con-

Table 3. Sex differences in hematology and blood biochemistry values of female and male wild, free-ranging ring-tailed lemurs from reserve (P1) and degraded habitats (P2) in the BMSR, Madagascar

Parameter	Female			Male			Wilcoxon signed-rank test z, p values
	mean±SD	min.–max.	n	mean±SD	min.–max.	n	
Monocytes, %							
P1	7.9±3.1	4–15	14	6.2±3.2	3–14	12	2.10, ≤0.04
P2	7.3±2.9	3–9	4	7.3±2.0	5–9	6	0.00, 1.00
Eosinophils, %							
P1	7.2±4.6	3–18	14	3.9±3.6	0–11	12	1.19, 0.05
P2	9.0±2.6	6–12	4	5.5±4.1	0–10	6	1.18, 0.23
Potassium, mEq/l							
P1	3.41±0.59	2.2–4.2	14	3.76±0.31	3.4–4.3	12	1.50, 0.13
P2	3.38±0.30	3.0–3.7	4	3.93±0.36	3.4–4.5	6	2.03, ≤0.04
TCO_2, mmol/l							
P1	24.4±3.2	19–29	14	27.6±2.5	24–32	12	2.31, ≤0.02
P2	20.8±2.9	17–23	4	24.2±3.1	21–29	6	1.61, 0.11

clusion that P2 lemurs are less hydrated than P1 lemurs. These findings are in contrast to a previous study of ring-tailed lemurs at BMSR which suggested that ring-tailed lemurs in marginal habitats were less hydrated than lemurs in reserve or degraded habitats based on differences in sodium, Cl^- and osmolality [Miller et al., 2007]. However, conclusions regarding hydration in the study of Miller et al. [2007] are tenuous as (1) these 3 measures are all highly correlated and not necessarily indicative of dehydration, (2) elevations of PCV, TP, BUN and Cr were not found, and (3) urine SG was not measured. Additionally, in the study of Miller et al. [2007], the marginal and degraded habitats were either within gallery forest or adjacent to gallery forest whereas the P1 lemurs live within a dry deciduous spiny forest. While the reserve gallery forest in both studies does suffer from livestock grazing and harvesting, P2 is severely degraded by these activities (fig. 1). Thus, the differences in habitat alteration between P1 and P2 are greater than the differences in habitat alteration between the reserve and degraded habitats of the study of Miller et al. [2007]. Also, data from only 1 male each were available from the reserve and degraded habitats in the study of Miller et al. [2007], and most study animals in each habitat were from the same troop. In the present study, the sex ratio was nearly 1:1, and the lemurs were members of multiple, separate troops.

P2 of BMSR is a disturbed xerophytic habitat. In contrast, Tsimanampesotse National Park (TNP), also in southwestern Madagascar (24°17′ S, 43°15′ E), is a relatively isolated xerophytic habitat with little human disturbance [Brinkmann et al., 2014]. TNP is next to a large carbonate playa lake and is comprised of palm savanna with introduced grasses, thorny bush vegetation and boabab trees growing on calcareous cliffs [Dutton et al., 2003]. Wild, free-ranging ring-tailed lemurs at TNP were judged to be more hydrated than captive lemurs based on lower values of TP, albumin, BUN, Cr and PCV [Dutton et al., 2003]. Lemurs at BMSR in the current study are less hydrated than the lemurs at TNP [Dutton et al., 2003], based on higher PCV,

TP, sodium, Cl^- and Cr (tables 1, 2). At TNP, lemurs have year-round access to water in sink holes and underground caves [Sauther et al., 2013], suggesting that water limitation, either natural or induced by human alteration of the habitat, is the cause of the differences in blood values between these two locations.

Alternatively, differences in PCV/HCT, Hb, TP, BUN, Cl^- and Ca^{2+} could reflect differing nutritional status between groups. A previous study at BMSR found that lemurs in degraded habitat had higher TP and albumin than lemurs in marginal and reserve habitat, which was thought to be due to consuming food of human origin [Miller et al., 2007]. Several studies comparing wild, free-ranging and captive lemurs found that captive animals had higher BUN, PCV, TP and/or albumin, which was attributed to captive diets that were likely higher in protein than the diets of free-ranging lemurs [Junge and Garell, 1995; Junge and Louis, 2002, 2005].

At BMSR, the most commonly eaten food items are present in both parcels but with varying relative abundances. During the dry season (April to October), lemurs in P1 and P2 fed primarily on *Tamarindus* fruit (60% of feeding time). However, during the wet season (November to March), the relative rankings of these favored food items differ between P1 and P2, with P1 lemurs relying more heavily on *Tamarindus* fruit than P2 lemurs [Yamashita et al., 2015]. The current study was conducted during the middle of the dry season, when lemurs in both parcels were spending the majority of feeding time consuming the same food items. At this time, the Sakamena River in P1 was dry, thus eliminating an important water source for lemurs in P1. While data indicate that lemurs spend the majority of feeding time consuming tamarind fruit [Yamashita et al., 2015], it is unknown what proportion of total time is spent feeding or looking for food. It is possible that lemurs in P2 are spending more time searching for and ingesting lower amounts of food, which could impact the hydration level. The understory of P2 is reduced due to livestock grazing and other human disturbance (fig. 1), thus eliminating important *L. catta* food resources [Sauther, 1998]. The remaining native arid spiny plant community of P2 may provide less dietary water than the reserve riverine gallery forest habitat of P1. Given the similar diet and limited water supply of the lemurs in both parcels during the dry season, it is reasonable to conclude that hematological and blood biochemistry changes are due, at least in part, to human alteration of the habitat. More information on feeding ecology and behavior, nutrient analysis of commonly consumed food items, and determination of the serum vitamin and mineral levels of animals at each site may help further clarify this point.

There were no statistically significant differences in leukocyte count or differential between habitats. This may be due to the large range of values and the small sample size from P2. However, sex differences were detected in 4 health parameters. P1 female lemurs had significantly higher percentages of monocytes than P1 males (table 3). A similar finding was reported by Miller et al. [2007] for lemurs at BMSR. Monocytosis can occur in response to chronic inflammatory conditions, such as bacterial or viral infections or neoplasia, or sometimes pregnancy. Documentation of pregnancy status and stage and serological screening for infectious diseases could help interpret the differences in monocytes between males and females in P1. This sex difference was not present in P2, possibly due to the smaller sample size (4 females, 6 males).

P1 female lemurs had significantly higher percentages of eosinophils than P1 males. A similar, though not significant, difference in percentage of eosinophils be-

tween females and males was present in P2 (table 3). Miller et al. [2007] found that female lemurs at BMSR had significantly higher eosinophil counts than male lemurs. Common causes of eosinophilia include allergies and parasitism. Quantification of endo- and ectoparasite loads and investigation into sex differences in use of environmental resources could help explain this sex difference.

Male lemurs in P1 had higher TCO_2 than female lemurs in P1. A similar, but not significant, pattern was present in P2 (table 3). Male lemurs in P2 had higher potassium levels than female lemurs in P2 (table 3). The biological significance of these differences is minimal since all values are within reference ranges for captive ring-tailed lemurs [Dutton et al., 2003; Teare, 2002].

A confounding factor in the statistical analyses for habitat effects is the fact that P1 and P2 differ in both the plant community composition and the degree of degradation. There is a gradual transition in habitat within BMSR, ranging from riverine gallery forest in the east to mixed dry deciduous and spiny forest in the west. Some P1 lemur troops reside in the western part of P1, where the habitat has more spiny forest influence. A study by Yamashita et al. [2015] indicates some similarity in forest structure between P1 and P2, as would be expected in distant parcels within the same continuous habitat. Specifically, trees and shrubs did not differ significantly in height and diameter at breast height between P1 and P2 (although P2 trees tended to be smaller than P1 trees). Secondly, all but one of the plant species identified were found in both P1 and P2 but with varying prevalence between the parcels. Notably, the density of tamarind trees, an important food source for *L. catta*, is lower in P2 than in P1. Without direct comparison between intact and degraded gallery forest and intact and degraded dry deciduous and spiny forest, it is difficult to determine definitively what roles habitat differences and variation in human disturbance play in the observed differences in health parameters.

BMSR is remote and lacks consistent electricity, precluding both short- and long-term sample storage. In addition, field seasons are frequently 4–6 weeks in length, and regular travel to distant health laboratories for sample testing is not feasible. Therefore, this study was designed to be completed in the field using portable technology and is inherently limited in scope compared to other health surveys of lemurs. However, this study highlights the value of point-of-care analyzers for collecting meaningful data in challenging field situations.

Long-term medical evaluations of wild, free-ranging lemur populations within higher quality protected reserves have provided baseline normal health values for lemurs [Miller et al., 2007], while results from this study add to our understanding of how these values may change with anthropogenic alterations. Given the greater human impact in P2, a pattern seen throughout southern Madagascar, biomedical indicators suggestive of decreased hydration in this study can provide empirical data to inform new conservation policies facilitating the long-term survival of this lemur community. Specifically, a better understanding of factors contributing to environmental stress for endangered and vulnerable lemur species is important for their protection and for the development of feasible conservation initiatives.

In addition, the health and success of lemur groups in both high-quality habitat and more challenging environments will inform the capacity for each species to cope under future habitat alteration. As recent evidence suggests a potential genetic population bottleneck among ring-tailed lemurs in the riverine forest area of BMSR [Parga et al., 2012], the long-term survival of these spiny forest lemurs is an imperative,

in order to maintain the health of the region's ring-tailed lemurs. Specifically, ring-tailed lemurs migrate as far as 20 km from their natal troops [Cuozzo and Sauther, unpubl. data]. As the BMSR P2 ring-tailed lemurs live only 5–10 km from the P1 troops, their genetic diversity and survival are central for the maintenance of a healthy, viable lemur population. Thus, these new health and biomedical data are vital for conservation efforts at this reserve.

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