Nimba Western Range Iron Ore Project, Liberia

Biodiversity Conservation Programme 2011-2015

Conservation Status of the Nimba Otter Shrew *Micropotamogale lamoteii* (Afrosoricida) within the ArcelorMittal Concession

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Contents

List of Abbreviations

AML	ArcelorMittal Liberia
BioPA	Biodiversity Preliminary Assessment
DSO	Direct Shipping Ore
EDGE	Evolutionary Distinct and Globally Endangered
ESIA	Environmental and Social Impact Assessment
FDA	Forestry Development Agency
GIS	Geographic Information System
IUCN	International Union for Conservation of Nature

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1. EXECUTIVE SUMMARY

The ArcelorMittal mining concession falls within one of the most important sites for mammal conservation in Africa. At least one mammal species is completely restricted to the Mt. Nimba range, with several others being endemic to the general region (including the Nimba otter shrew *Micropotamogale lamottei*).

An intensive survey of *Micropotamogale lamottei* was conducted over a 17-day period in January 2013, during the dry season. Emphasis was placed on developing techniques for the live capture of individuals.

Two types of funnel traps were employed in the capture of *Micropotamogale lamottei*: those made from wire-mesh and those made with bamboo for a total of 1011 trap-nights. In addition to physical trapping, nine Reconyx (PC 800) camera-traps were set alongside rivers, streams and other wetlands specifically to capture images of this species. Interviews with local hunters provided supplementary data on the presence and distribution of this species in the Nimba area.

A detailed description of each sampling site was made (such as habitat, substrate), which included measuring several physical water parameters such as stream width, depth, water temperature, pH, electrical conductivity and total dissolved solids.

Five *M. lamottei* were captured during this study with a further four animals being obtained from hunters that had been killed (or found dead) prior to this study, and had been preserved as specimens. Four more sites were identified by hunters from which this species had been trapped in the recent past. In addition to the data collected during this study, five specimens were collected in two previous studies (four during the Wild Chimpanzee study and one during Phase I of the ESIA), and five more reports were made by BioPA. All in all, there are 23 records of *M. lamottei* from the AML concession. These 23 records are mapped using GIS.

Where possible, standard museum measurements of specimens were taken and are presented here.

With one exception, there was no obvious relationship between any of the physical parameters of the wetlands and the distribution of *M. lamottei*. The exception was water depth, which was statistically greater at sites where *M. lamottei* had been captured. This result is suspected not to be biologically meaningful. Alternatively, it may indicate that shallow streams do not support this species (perhaps as a result of the reduction of its food supply).

A detailed review of the literature is made with a view to assist conservation management decisions. This is divided into four sections: global distribution; habitat selection; foraging ecology and demography. These are thought to be critical areas for the conservation of *M. lamottei*. Gaps in our knowledge are highlighted.

Recommendations for future work are made. These include continuation of the trapping during different seasons, radio-tracking and publication of data collected to date.

2. INTRODUCTION

The ArcelorMittal Liberia (AML) mining concession falls within the Mt. Nimba region of West Africa which represents one of the most important sites for mammal conservation on the continent (Brooks et al. 2001; Fahr et al. 2006). Mt. Nimba straddles Liberia, Guinea and Ivory Coast and rises to 1,768m (in Guinea). Highland areas above 1,000m are restricted in West Africa, and as a result, levels of endemism tend to be very high in these areas. At least one mammal species is endemic to Mt. Nimba (the bat *Hipposideros lamottei*) (Brosset 1985). In addition, several small mammal species have highly restricted global distributions centred on the Guinea/Liberia border including the bats *Hipposideros marisae* and *Rhinolophus ziama* (Rosevear 1965; Fahr et al. 2002), and the shrew *Crocidura nimbae* (Hutterer 2005), and the Nimba otter shrew *Micropotamogale lamottei* (Vogel 1983). Many other species are endemic to the Upper Guinea rainforest block such as the rodents *Grammomys buntingi* and *Praomys rostratus* (Musser & Carleton 2005). Hence, ArcelorMittal has global responsibilities with respect to environmental and ecological management of this concession.

The Nimba otter shrew *Micropotamogale lamottei* (which was only described to science in 1954) has a very limited global distribution, occurring only in Liberia, Guinea and Ivory Coast centred on Mt. Nimba (Vogel 1983). Its closest relatives are the Rwenzori otter shrew *Micropotamogale ruwenzorii* from the Albertine Rift and the giant otter shrew *Potamogale velox* from the Congo basin. These three species are the only representatives of the family Tenrecidae on mainland Africa; the remaining 30 species being restricted to Madagascar. *Potamogale velox* is currently not considered threatened whilst *Micropotamogale ruwenzorii* is listed as Near Threatened. However, *Micropotamogale lamottei* is listed as Endangered (IUCN 2013). The reasons given by IUCN (2013) for this listing are:

“Suitable habitat is threatened by mining, agricultural development and increased human activities. Mining activities in Liberia have devastated large regions of suitable habitat (Nicoll and Rathbun 1990) and wetland rice agriculture introduced in 1980 to the Nimba region has resulted in large-scale habitat destruction (P. Vogel, unpubl). Habitat conservation is considered to be ineffective. The increased use of fish traps and nets are a serious problem as human density increases.”

In addition, this species is on the list of the top 100 Evolutionarily Distinct and Globally Endangered (EDGE) specie (www.edgeofexistence.org/mammals). Hence, the Nimba otter shrew is one of the most important animal species from the conservation perspective of the ArcelorMittal concession. The first report of *Micropotamogale lamottei* from the AML concession was in the 1970s (Coe 1975). More recently, several individuals were captured during the Phase 1 DSO ESIA ecological surveys in 2010 and 2011. All these records are synthesised and reviewed in this report.

2.1 Objectives and Expected Outputs

The objective of this study was to establish and implement a research programme to investigate the ecology, status and distribution of the Nimba otter shrew in northern Nimba.

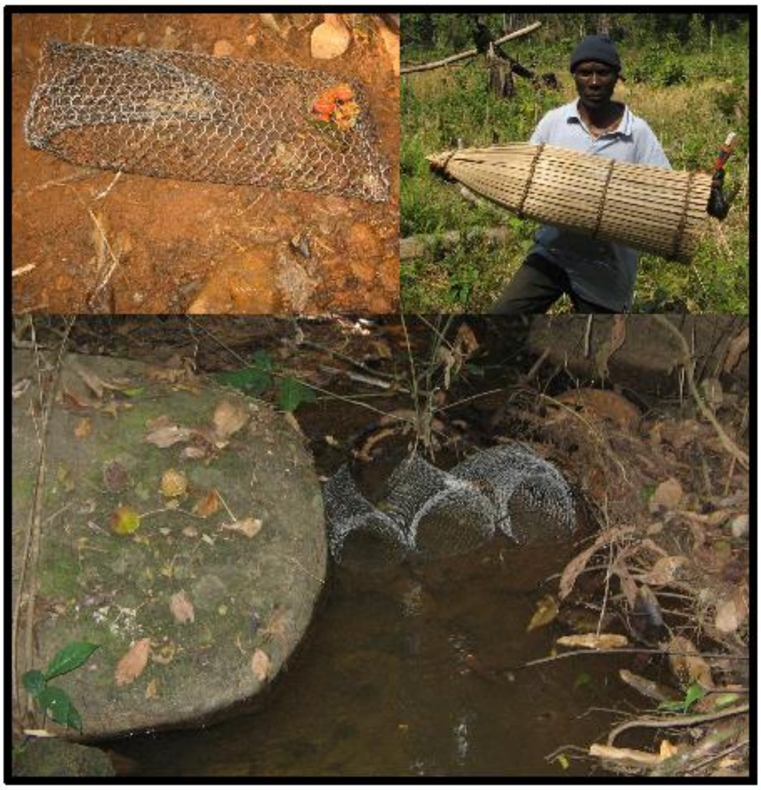
The expected outputs of this study were to:

- Establish the presence of the Nimba otter shrew by various survey methods including trapping, camera-traps, and interviews.
- Supervise the research and training of a field team.
- Establish a project database.
- Draft a progress report with recommendations for the next stage of the project.

3. METHODS

Nimba otter shrews were surveyed using three different techniques. 1) Local hunters were employed at Zolowee, Gbapa, Bonlah, and Vanyampa to capture this species and to collect information on incidental captures by other community members. The hunters used either traditional baskets designed for capturing crabs (see Figure 1) or our home-made funnel traps (see below). 2) Between 6 and 9 camera traps (Reconyx PC800) were set at 7 sites (see Figure 2, Appendix I). 3) Over 100 home-made funnel traps made of chicken wire (see Figure 1, Appendix I) were set at 37 sites throughout the AML concession (Figure 3). These traps were baited with crabs and set for 2-4 nights at each site. An attempt was made to block off the entire stream with these traps (Figure 1). Total trapping effort was 1011 trap-nights.

Figure 1. Pictures showing the traps used during this study with wire funnel traps (top left), and traditionally-made crab baskets (top right). The traps were set in such a way as to block off a stream (if small enough) or portion of a river (if larger) as shown in the figure (bottom).

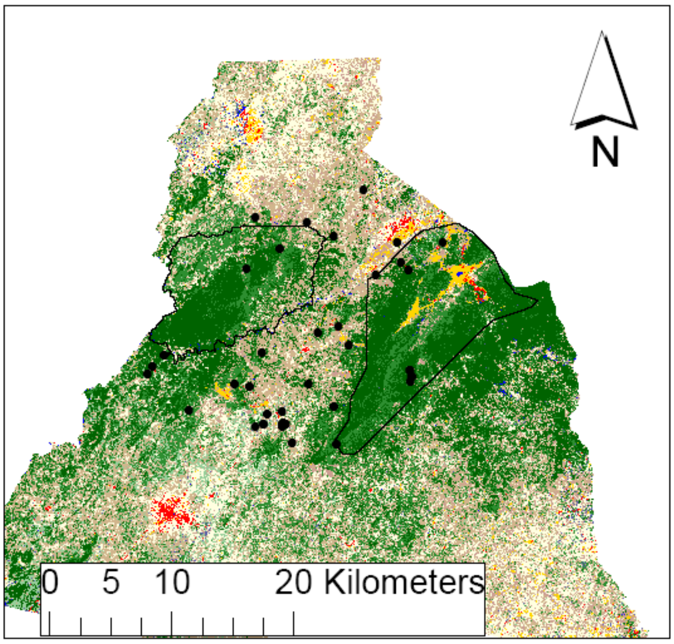


In addition to the trapping of otter shrews, local community members were interviewed about the capture of otter shrews in locally-made crab basket traps. All people that were asked knew of the otter shrew, but only a few were able to lead us to the exact point where they had previously captured an individual.

Figure 2. A picture of the Reconyx camera trap set for capturing images of the Nimba otter shrew.

At each trapping locality (whether by us or by hunters or local community members), we measured several physical parameters of the wetland. We measured the width and depth of the stream, the water temperature, total dissolved solids (ppm), electrical conductivity (µS) and pH. Where possible we also took standard museum measurements of any Nimba otter shrew specimens.

Figure 3. The sampling localities (black dots) visited during this survey overlaid on a forest cover map (dark green showing intact forest) and the boundaries on East Nimba Nature Reserve (to the right) and Gba Community Forest (to the left). The full details of each sampling locality are presented in Appendix I.



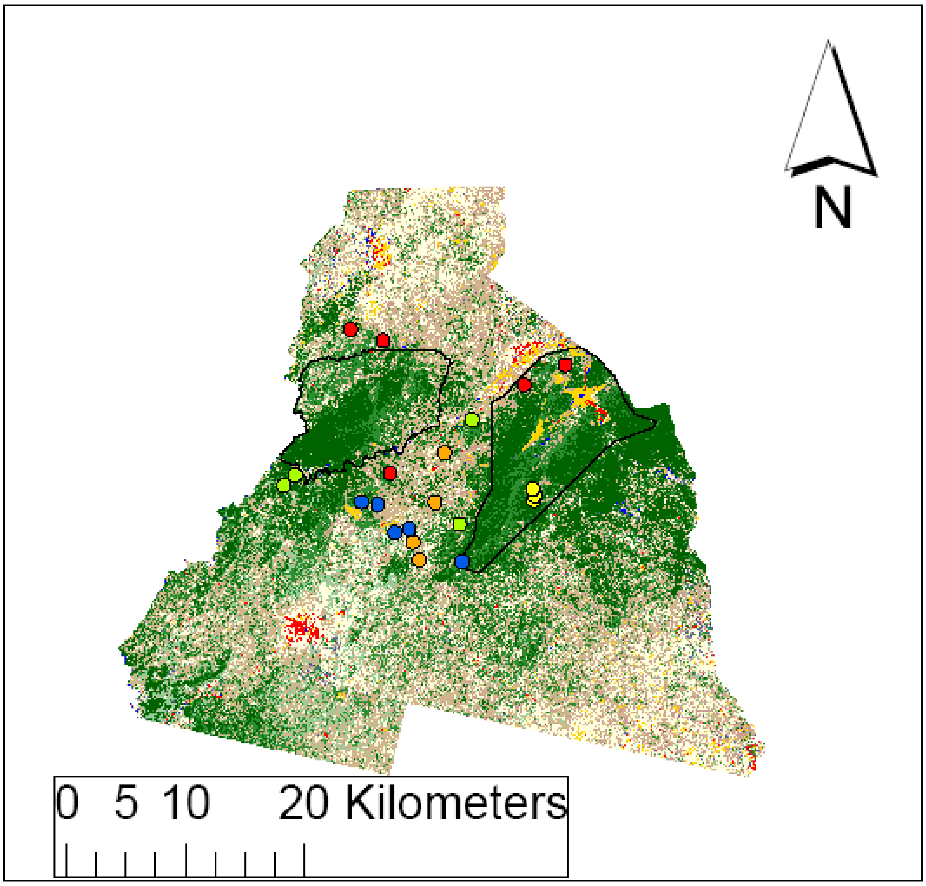
Data analysis

A logistic regression was performed on the presence or absence of Nimba otter shrews at a particular site and the physical parameters of the wetland. All statistical analyses were performed in the program R.

4. RESULTS

A total of 23 Nimba otter shrews have been recorded from the AML concession area since 2009 (when the BioPA studies were initiated) (Figure 4, Appendix II). Of these, five were captured during this survey and four more were recovered from local hunters. Specimens from previous surveys include four collected during the Wild Chimpanzee Foundation surveys, and one during Phase 1 (Phalan 2010). The remaining records are based on four specimens reported by local community members who had recently captured the species in home-made crab-baskets and five records of the spoor of this species based on the BioPA report.

Figure 4. A map showing the distribution of the 23 Nimba otter shrew records from the AML concession. Red – specimens collected during the current survey; blue – specimens collected during previous surveys; orange – specimens collected by local hunters prior to the current survey; green – specimens reported by local community members; yellow – footprints seen during BioPA. Full details are presented in Appendix II.



Of the total of 1011 trap-nights in this study, 872 trap-nights were with the wire funnel traps and 139 trap-nights were with the traditional basket traps. In previous surveys (conducted by the Wild Chimpanzee Foundation survey), a total of 795 trap-nights were with traditional basket traps. If the capture data are combined for this study and previous studies, then trap success rate was 0.5% for both types of traps (4 animals in wire funnel traps and 5 in traditional basket traps). For camera traps the total was 104 trap-nights. Possibly a single otter shrew was recorded on the cameras (but this could not be confirmed) giving a maximum trap success rate of 1.0%. This is double the rate of that for the funnel and basket traps, but since the identification of the specimen remains uncertain, this comparison should be made with caution.

A few specimens could be weighed and/or measured. These are presented in Figure 5 below.

Figure 5. Mass and measurements of Nimba otter shrews captured during this survey; n = sample size.

Measurement	n	Mean	Range
Mass (g)	4	66.8	50-81
Head-body length (mm)	2	128.0	115-140
Tail length (mm)	2	128.0	115-140
Hindfoot length (mm)	2	21.5	21-22

There was no apparent relationship between the distribution of Nimba otter shrews and any of the measured water parameters (Figure 6). The full details for the measured parameters of each locality are presented in Appendix III. The results of the logistic regression indicated that only one of the parameters was significantly associated with the presence of Nimba otter shrews, that of stream depth. Stream depth was significantly deeper where Nimba otter shrews were captured compared with where they were not (26.5 cm versus 17.7 cm). Whether this is also biologically significant is currently not known. It could be that deeper streams have larger crab populations, which is the dominant prey of the Nimba otter shrew.

Figure 6. Site characteristics at locations where Nimba otter shrews were present and absent averaged out over all the sites that were sampled.

Parameter	Present	Absent
Stream width (m)	2.57	2.63
Stream depth (cm)	26.5	17.7
Flow rate (m/sec)	0.10	0.12
Water temperature (°C)	21.1	21.5
Total dissolved solids (ppm)	16.7	14.8
Electrical conductivity (µS)	33.4	30.0
pH	6.76	6.93

5. OVERVIEW OF THE ECOLOGY OF *MICROPOTAMOGALE LAMOTEII*

Two relevant questions that need to be addressed with regards to this species are: 1) what do we know about the ecology of the Nimba otter shrew? And, 2) how does this affect conservation action? These two questions will be addressed in the following section.

From a conservation perspective, the following ecological information is essential. Without this basic ecological information, it would be difficult to develop a sensible conservation management plan for this species.

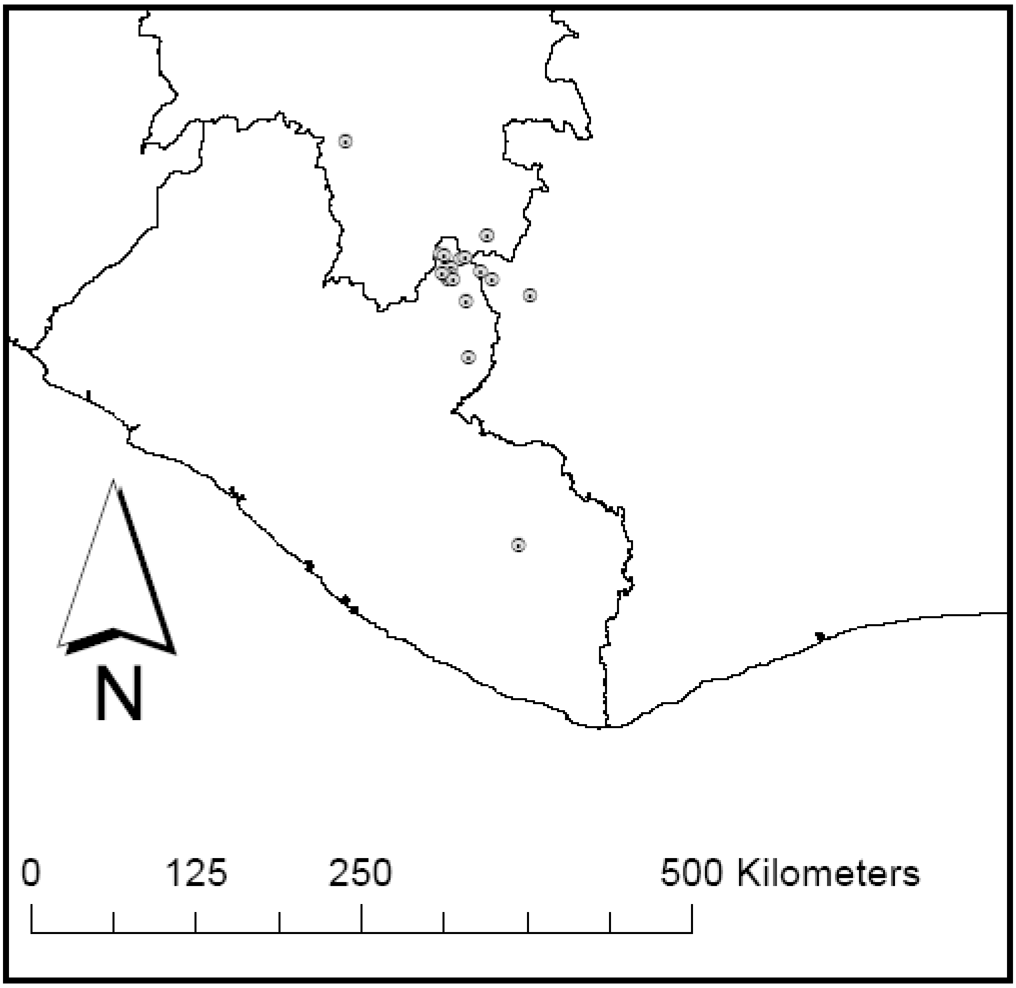
- Distribution and global range
- Habitat selection and spatial ecology
- Diet and foraging ecology
- Demography (reproductive rate, survival, longevity, etc)

The global distribution of the Nimba otter shrew was mapped by Vogel (1983). At that time it was not known from the AML concession, although it was predicted to be present (Coe 1975) and had been recorded from Guinean Nimba (Guth *et al*. 1959). The current distribution of the species (based on captured specimens) is shown in Figure 7. Most records come from within a 50 km boundary of Mount Nimba with outliers at Ziela (to the north-west) and Putu hills (to the south-east). An important question that has major implications for the conservation of this species in the AML concession is its exact area of occupancy. Does the species occur uniformly throughout this area? Or does the species have a patchy distribution? Unfortunately, with the information at hand, it is not possible to answer this question. The species may be present in the intermediate areas, which future fieldwork would have to confirm. However, the precautionary principle requires that such assumptions be avoided. As such, its distribution should be considered to be restricted to these three patches until such time that specimens have been obtained from elsewhere.

Prior to this study, very little was known about the habitat requirements of the Nimba otter shrew. Vogel's (1983) study showed that of 50 specimens whose provenance was known, 15 came from rivers, 31 from streams and 4 from swamps. Hence the majority of records were from streams (although what constituted a river and what constituted a stream was not defined). The current study showed that the Nimba otter shrew occupies a wide range of wetland habitats from small streams to larger rivers without any statistically significant association except for water depth (which may or may not be biologically meaningful). Despite the progress made in understanding this species habitat requirements, our knowledge of its spatial ecology (how it uses its habitat) is still almost completely absent.

Prior to this study, the only ecological observations made on this species were by Vogel (1983), based on four individuals in captivity (of which one survived a year and a half). Although a rigorous food choice experiment was not conducted, the author observed that crabs and fish (particularly catfish of the family Siluridae) were the preferred prey, and that it fed on about 70 g per day (the equivalent of its body weight).

Figure 7. The global distribution of *Micropotamogale lamottei* based on museum and literature records, showing the importance of the Nimba mountain range.



Demographic parameters are vital for studies of population persistence (e.g. predicting extinction), yet few data are available for the Nimba otter shrew. Typically the demographic parameters used in such studies include reproductive output (number of offspring born per female per annum), and survival rate (preferably separate for adults and juveniles). The only demographic data available for this species is mean litter size (based on births and litter counts) = 2.6 (range = 1-4, n = 11) (IUCN 2013). It is not known whether females can give birth more than just once per annum, but it would be highly atypical of small mammals if this were not the case. The survival rate is unknown and can only be estimated based on a capture-mark-recapture study which requires that a large sample of animals be captured alive and then at least some of them recaptured at a future time. Based on the various studies conducted to date, this would not appear to be feasible; hence this parameter is likely to remain unknown for the foreseeable future.

6. RECOMMENDATIONS

This study has contributed to the understanding of the ecology of the Nimba otter shrew primarily by quantifying its habitat requirements and developing a technique for its capture. However, there are still some important parts of its ecology that are poorly understood or completely unknown, but which are important for its conservation. The recommendations made here are specifically for closing these gaps in our knowledge. The recommendations are listed below, in no particular order of importance. Two criteria were used to select the following recommendations: conservation implications; and whether the work is feasible (the latter is a subjective assessment based on the field experience gained in the current study).

1. Extending the habitat study. The current study was conducted during the dry season (January). Ecological conditions may change significantly during the wet season. For this reason, it is suggested that the two further surveys be conducted, during April/May and August/September 2013. The field team was trained up to conduct this work independently of the principal consultant (see Outcomes, below). Hence, I would not need to be present for this work to be accomplished.

2. Telemetry study. A major gap in our knowledge of the Nimba otter shrew is in the way that it uses its habitat, and how it spaces itself within that habitat. The conservation implications of both these questions are obvious and important. These questions can readily be answered by a radio-tracking (telemetry) study. A minimum of five (but preferably 10) animals will need to be captured and fitted with collars carrying a radio-transmitter. The signal from this transmitter can be picked up by a receiver which would then allow an observer (or a team of observers) to follow the animal at a safe distance. The location of the animal can then be pin-pointed with great accuracy, and the accumulation of points over multiple nights will allow the estimation of its home range, characterization of its resting sites, time spent foraging in and out of water, etc. This study would need to be implemented and supervised by a trained wildlife ecologist (with experience in tracking small mammals in African landscapes), but could be completed by the field team. Capture of otter shrews will need to be done by a large number of wire funnel traps and/or traditional basket traps. At the trap success rate of 0.5%, on average 10 animals will be caught after 2,000 trap-nights (or 100 traps set over 20 nights). The capture of otter shrews may be the limiting factor in this study and should not be underestimated.

3. Prey availability study. Based on previous studies (see Overview of Ecology of *Micropotamogale lamottei*, above), crabs and silurid catfish are the primary prey items in the diet of the Nimba otter shrew. The persistence of the Nimba otter shrew within wetlands in the AML concession will, therefore, depend on the persistence of these prey organisms. Hence, the impact of mining on the Nimba otter shrew in the AML may be determined by what happens to the crabs and catfish. It is recommended that a study be initiated on the population densities of crabs and catfish in various streams and rivers in the AML concession, with the primary objective of determining the effect of mining iron ore on these two groups of organisms. It should be noted that this study may be important of its own sake because at least one crab species (*Liberonautes lugbe*) is endemic to the AML region (IUCN 2013).

4. Preparation of publications. There is now enough information and data collected from the Nimba otter shrew within the AML concession to allow publication of the results. It is suggested that one scientific publication be written up and submitted to an appropriate peer-reviewed journal. A second publication could be written up as an extended article or small booklet reviewing all that is known about the species. This article should be written for the lay-person and scientist alike and perhaps printed with AML funding so as to ensure that it is glossy and fully illustrated (thereby attractive to readers).

7. OUTCOMES

The current study has provided new insights into the ecology of the endemic Nimba otter shrew, as well as synthesizing all available ecological information on the species. The scientific outputs of this study have been dealt with above and will not be repeated here. This study, however, also had a non-scientific objective: the supervision and training of a field team. In my opinion, this was successfully achieved. The research team comprised David Carl, Peter Farnloe and Moses Darpey. David recently graduated from the University of Liberia (2011), whereas Peter and Moses have been involved in bio-monitoring as field assistants to various ecological and taxonomic studies. This team was trained over the course of this study to be able to capture the Nimba otter shrew and assess the associated habitat independently. The team became so proficient at this that I have no doubt that they could continue with the two further surveys (see Recommendations above) without my presence.

Figure 6. Photographs of David Carl, Peter Farnloe and Moses Darpey showing them setting traps and taking various measurements in the field.

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APPENDIX I

Details of all the localities that were surveyed for Nimba otter shrew, or visited during this study.

Site	Name	Tributary of	Latitude	Longitude	Altitude	Date	Habitat	Substrate	Trap nights	Cameras
Site 01	Coldwater	Dayea (St John)	7.54875	-8.54131	573	Jan 2013	Primary forest	Pebbles and rocks	75	6
Site 02	Doublin	Yiti	7.49705	-8.60280	485	Jan 2013	Primary forest and farmland	Sand and mud	20	0
Site 03	NA	Yiti	7.48149	-8.64463	464	Jan 2013	Primary forest	Sand and rocks	12	0
Site 04	NA	Seka (and then Dayea)	7.56388	-8.51019	588	Jan 2013	Primary forest	Sand and rocks	20	6
Site 05	NA	Dayea	7.56406	-8.54415	508	Jan 2013	Swamp in urban area	Mud	62	0
Site 06	Gwehtee	Gwehzolo (Yah)	7.42837	-8.62697	464	Jan 2013	Secondary forest and farmland	Mud	21	0
Site 07	Kpahquelleh	Yiti	7.45886	-8.61013	475	Jan 2013	Primary forest and farmland	Mud	20	0
Site 08	Yea	Gwetee	7.42899	-8.62965	468	Jan 2013	Secondary forest and farmland	Mud	39	0
Site 09	NA	Kahn	7.57849	-8.61111	521	Jan 2013	Secondary forest	Mud and rocks	32	5
Site 10	NA	Kahn	7.55960	-8.63130	709	Jan 2013	Secondary forest	Sand and rocks	28	4
Site 11	Carwasher	Dayea	7.53923	-8.55994	497	Jan 2013	Secondary forest	Sand and pebbles	20	0
Site 12	NA	Kahn	7.56910	-8.59111	504	Jan 2013	Secondary forest	Mud	30	0
Site 13	NA	Kahn	7.60351	-8.56887	515	Jan 2013	Secondary forest	Mud	30	0
Site 14	NA	Dayea	7.54347	-8.53563	668	Jan 2013	Primary forest	Pebbles and rocks	20	9
Site 15	Kwekeleh	Dayea	7.47988	-8.71734	413	Jan 2013	Farmland	Mud	40	0
Site 16	Bong	Kolleh (St John)	7.47186	-8.72587	440	Jan 2013	Primary forest	Mud	48	0
Site 17	Suleyee	Gwetee	7.42725	-8.62950	468	Jan 2013	Secondary forest and farmland	Mud	20	0
Site 18	Yea	Gwetee	7.43010	-8.62874	464	Jan 2013	Secondary forest and farmland	Mud and rocks	20	0
Site 19	NA	Yah	7.43924	-8.69884	468	Jan 2013	Primary forest	Sand and mud	60	0
Site 20	NA	Yiti	7.50161	-8.58793	491	Jan 2013	Secondary forest	Sand and mud	40	0
Site 21	Yiti	Dayea	7.48741	-8.57993	515	Jan 2013	Secondary forest and farmland	Pebbles and rocks	20	0
Site 22	Zalon	Gweneh (Yah)	7.42871	-8.64339	471	Jan 2013	Secondary forest	Sand	6	0
Site 23	Gweneh	Gwehzolo (Yah)	7.42858	-8.64381	470	Jan 2013	Secondary forest	Sand	5	0

Site	Name	Tributary of	Latitude	Longitude	Altitude	Date	Habitat	Substrate	Trap nights	Cameras
Site 24	Kponezolo	Gweneh (Yah)	7.42735	-8.64967	848	Jan 2013	Farmland	Sand and mud	8	0
Site 25	Bong	Kolleh (St John)	7.46625	-8.72957	414	Jan 2013	Primary forest	Sand and pebbles	40	4
Site 26	Gwehzolo	Yah	7.41479	-8.62236	463	Jun 2012	Secondary forest and farmland	Sand and rocks	-	-
Site 27	Veleeh	Gba (St John)	7.54441	-8.65593	445	Jan 2013	Secondary forest and farmland	Sand and pebbles	30	0
Site 28	NA	Gba (St John)	7.58288	-8.64946	454	Jan 2013	Secondary forest	Mud	20	0
Site 29	Coldwater	Dayea	7.54630	-8.54162	582	Jan 2013	Primary forest	Pebbles and rocks	52	-
Site 30	Coldwater	Dayea	7.54640	-8.54188	578	Jan 2013	Primary forest	Pebbles and rocks	40	-
Site 31	Coldwater	Dayea	7.54673	-8.54219	575	Jan 2013	Primary forest	Pebbles and rocks	40	-
Site 32	Coldwater	Dayea	7.54611	-8.54105	573	Jan 2013	Primary forest	Pebbles and rocks	48	-
Site 33	Coldwater	Dayea	7.54832	-8.54124	574	Jan 2013	Primary forest	Pebbles and rocks	45	8
Site 34	Liaba	Dayea	7.52252	-8.58176	484	2010	Secondary forest and farmland	Rocks and mud	-	-
Site 35	Leyee	Gba (St John)	7.59116	-8.67451	426	Jan 2013	Primary forest and farmland	Sand and rocks	44	0
Site 50	Gweneh	Yah	7.43594	-8.64067	494	2011	Secondary forest	Sand and rocks	210	-
Site 51	Gwetee	Yah	7.43864	-8.62956	477	2011	Secondary forest	Sand	210	-
Site 52	NA	Dayea	7.45717	-8.65383	560	2011	Secondary forest	Sand	210	-
Site 53	Coldwater	Yah	7.41339	-8.58936	530	2011	Primary forest	Sand and pebbles	165	-
Site 54	Tokadeh swamp	Dayea	7.45853	-8.66507	585	May 2010	Secondary forest	Mud	-	-
Site 55	NA	Yah	7.44204	-8.59102	501	May 2010			-	-
Site 56	NA	Yah	7.46053	-8.53437		Jan 2009			-	-
Site 57	NA	Yah	7.46390	-8.53295		Jan 2009			-	-
Site 58	NA	Yah	7.46426	-8.53352		Jan 2009			-	-
Site 59	NA	Yah	7.46874	-8.53462		Jan 2009			-	-
Site 60	NA	Yah	7.46915	-8.53472		Jan 2009			-	-

APPENDIX II

The details of the 23 Nimba otter shrew records collected during the current survey or previous surveys.

Field No	Known date	Approx date	Collector/Observer	Site	Latitude	Longitude	Comment
S01	15-Jan-13		Ara Monadjem	Site 01	7.54875	-8.54131	This survey
S03	17-Jan-13		Ara Monadjem	Site 03	7.48149	-8.64463	This survey
S04	17-Jan-13		Ara Monadjem	Site 04	7.56388	-8.51019	This survey
S28	28-Jan-13		Ara Monadjem	Site 28	7.58288	-8.64946	This survey
S35	28-Jan-13		Ara Monadjem	Site 35	7.59116	-8.67451	This survey
S02		Sept 2012	Rufus Thompson	Site 02	7.49705	-8.60280	Caught after Wild Chimpanzee Foundation survey
S06	17-Aug-11		Alphonso Gbokolo	Site 06	7.42837	-8.62697	Caught after Wild Chimpanzee Foundation survey
S07		Sept 2012	Rufus Thompson	Site 07	7.45886	-8.61013	Caught after Wild Chimpanzee Foundation survey
S26		June 2012	Nyan Santo	Site 26	7.41479	-8.62236	Caught after Wild Chimpanzee Foundation survey
-	29-Jan-09		BioPA	Site 60	7.46915	-8.53472	Footprints seen during BioPA
-	29-Jan-09		BioPA	Site 59	7.46874	-8.53462	Footprints seen during BioPA
-	27-Jan-09		BioPA	Site 58	7.46426	-8.53352	Footprints seen during BioPA
-	27-Jan-09		BioPA	Site 57	7.46390	-8.53295	Footprints seen during BioPA
-	27-Jan-09		BioPA	Site 56	7.46053	-8.53437	Footprints seen during BioPA
-	06-May-10		Ben Phalen	Site 54	7.45924	-8.66616	Phase 1 survey
-	05-May-10		James Yelou	Site 55	7.44204	-8.59102	Reported by hunter during BioPA
-			Saye Yeawon	Site 16	7.47186	-8.72587	Reported by hunter during current survey
-			Saye Yeawon	Site 15	7.47988	-8.71734	Reported by hunter during current survey
-		2010	Sunday Wallace	Site 34	7.52252	-8.58176	Reported by Peter Farnloe
-		2010/2011	Project team	Site 53	7.41339	-8.58936	Wild Chimpanzee Foundation survey
-		2010/2011	Ouo Souah	Site 52	7.45717	-8.65383	Wild Chimpanzee Foundation survey
-		2010/2011	Frederik Souah	Site 51	7.43864	-8.62956	Wild Chimpanzee Foundation survey
-		2010/2011	Roger Cooper	Site 50	7.43594	-8.64067	Wild Chimpanzee Foundation survey

APPENDIX III

Physical and chemical characteristics of the sites sampled for Nimba otter shrew.

Site	Width (m)	Depth (cm)	Water temp (degC)	TDS (ppm)	Electrical Conductivity	pH	Flow rate (m/s)
Site 01	3.70	18	18.8	16	33	7.81	0.167
Site 02	1.70	20	21.4	14	29	6.82	0.033
Site 03	0.80	15	21.1	10	20	6.65	0.100
Site 04	2.20	12	19.7	38	77	7.53	0.200
Site 05	2.00	40	20.6	10	20	6.93	0.000
Site 06	4.40	50	17.1	5	11	6.84	0.083
Site 07	1.25	22	19.1	7	15	6.62	0.125
Site 08	3.00	26	17.3	7	14	7.33	0.038
Site 09	3.70	20	17.0	16	32	7.02	0.143
Site 10	1.30	14	21.2	6	13	5.94	0.125
Site 11	4.00	25	20.4	54	109	7.61	0.056
Site 12	0.90	6	23.0	9	19	7.16	0.077
Site 13	1.65	18	20.4	27	55	7.10	0.091
Site 14	2.30	18	21.2	8	18	7.42	0.167
Site 15	2.80	37	21.8	16	32	7.08	0.063
Site 16	2.25	30	24.0	21	42	6.38	0.000
Site 17	1.00	13	22.2	2	4	6.03	0.045
Site 18	2.45	25	22.5	7	14	6.48	0.067
Site 19	1.40	10	21.1	10	21	6.45	0.143
Site 20	2.00	20	23.5	5	11	6.92	0.050
Site 21	4.90	20	23.1	4	9	6.58	0.250
Site 22	1.40	20	21.4	7	15	6.18	0.111
Site 23	4.55	10	21.5	22	44	6.48	0.200
Site 24	1.00	10	22.4	18	36	6.74	0.100
Site 25	2.80	8	21.6	17	36	6.79	0.143
Site 26	5.70	94	22.1	10	20	6.13	0.167
Site 27	4.90	23	22.5	16	32	7.10	0.167
Site 28	2.00	15	22.4	20	39	7.04	0.000
Site 29	2.80	19	22.5	17	34	7.32	0.143
Site 30	2.90	20	22.5	18	36	7.41	0.125
Site 31	2.60	19	22.5	18	36	7.33	0.143
Site 32	3.30	11	21.5	22	44	7.50	0.125
Site 33	3.65	12	21.5	20	40	7.54	0.167
Site 34	2.00	34	23.1	31	61	7.10	0.167
Site 35	4.00	25	19.4	16	32	6.94	0.100
Site 50	4.80	21	21.2	45	86	6.54	0.083
Site 51	1.30	20	22.5	3	6	6.27	0.167
Site 52	1.30	10	21.2	16	34	6.85	0.071
Site 53	0.90	9	21.5	5	10	6.48	0.250
Site 54	100.00	19	21.8	10	21	5.86	0.000