Pygmy Hippo Research and Conservation project

Gola Rainforest National Park

Sierra Leone

Sponsored by Zoo Basel, Switzerland

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Pygmy Hippo Research and Conservation Project
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Summary

The Pygmy Hippo Research and Conservation project of the Gola Rainforest National Park (GRNP) in southeastern Sierra Leone, implemented from May 2013 to April 2014, focused on five major activities: 1) Reconnaissance surveys along streams inside the GRNP, 2) Testing and implementation of a new survey design along focal streams, 3) Camera trap survey following a new design, 4) Dung sampling for conservation genetic analyses and 5) Environmental education activities. The team consisted of one project coordinator from the GRNP/RSPB, two Research Technicians and one MSc-student who wrote his thesis on part of the research of this project. Furthermore, the team was supported by two environmental education specialists from the GRNP and many community members were engaged as casual labourers throughout field activities.

In total, parts of 24 different streams were surveyed on 54 survey trips using either reconnaissance or two newly developed survey designs. Camera traps were deployed close to two selected focal streams during a total of 675 trapping days, also following a newly developed deployment design. Together with further opportunistic surveys, these methods recorded 81 pygmy hippo signs (e.g. footprints, trails, dung), including 13 separate recording events on the camera traps with a total of 167 pygmy hippo pictures. However, our findings revealed that pygmy hippos are found in only very few areas inside GRNP. This confirmed the previous assumption that in our study area the major part of the present pygmy hippo population occurs in the surrounding of the national park close to larger streams, i.e. the unprotected community land. The newly developed survey designs form the basis for the methodology chosen for future pygmy hippo surveys in the Biodiversity Monitoring Plan for the Gola REDD project.

The environmental education activities focused especially on sensitization meetings with communities and training for teachers who are running nature clubs in their various schools in order to include information on pygmy hippos and their conservation in the teaching curriculum. Produced education materials that were also distributed in communities at the start of each survey trip, were posters, bumper stickers, pygmy hippo information sheets and T-Shirts.

Our findings highlight the need for community-based conservation activities, in order to ensure the long-term survival of pygmy hippos in the Gola Forest region. Ongoing and future activities include continuous sensitization activities in communities and schools as well as land-use planning for agricultural activities. Furthermore, the GRNP plans to introduce a community youth conservation volunteer programme, especially targeting unemployed youth from forest edge communities. Selected youth will be trained in wildlife monitoring (incl. pygmy hippo monitoring if funds are available) and will become ambassadors for the threatened wildlife species occurring in and around GRNP, in particular the pygmy hippo, by actively participating in and leading on research, conservation and sensitization activities.

Introduction

The Gola Rainforest National Park (GRNP) is the largest remaining area of lowland Upper Guinea tropical forest in Sierra Leone. It is also one of the most diverse and best protected areas within the entire range of the Upper Guinea forest ecosystem (Guinea to western Togo), one of the world's most important biodiversity hotspots (Mittermeier et al. 2004). Throughout different research activities in recent years (Klop et al. 2008, Hillers & Muana 2011, Garteh 2013, Hillers 2013), it has been shown that the GRNP and its surroundings provide some of the most important and last natural habitats for the Endangered pygmy hippopotamus (*Choeropsis liberiensis*). This cryptic and hardly seen animal only occurs in four countries (Sierra Leone, Liberia, Guinea, Côte d'Ivoire). Its few remaining habitats are highly fragmented and only little is known about its population sizes, behaviour and ecology (Mallon et al. 2011).

Between 2008 and 2012 various research activities, partly focusing on pygmy hippos (e.g. pygmy hippo projects funded by Basel Zoo from 2010 to 2012), recorded many signs of pygmy hippos in the Gola region. Besides the general attempt to contribute to an effective conservation of the pygmy hippo to ensure its long-term survival in the Gola region, four major issues highlighted the urgent need to seek funding for a follow up project on pygmy hippos in this area:

1) Between 2008 and 2012, almost all pygmy hippo signs were recorded along the rivers in the community areas outside the GRNP. However, this observed distribution may result from a sampling bias as previous surveys especially focused on areas along larger streams that are mainly located outside of the GRNP. If it is further confirmed that indeed pygmy hippos mainly occur in unprotected land outside of the GRNP, this needs to be taken into account for the GRNP activities, especially the work with the communities around the GRNP and be reflected in the conservation strategy of the GRNP.
2) So far, there are no standardized survey techniques for pygmy hippos and most data result from reconnaissance surveys. However, the pygmy hippo is one of the High Conservation Value (HCV) species of the GRNP and thus one of the focal species also for future Biodiversity Monitoring activities of the GRNP under the Gola REDD project that is supposed to secure funding for the effective protection of the GRNP and its biodiversity for the next 30 years. A standardized survey design that can be followed for future research at GRNP is needed to allow for comparison of data of future surveys with the baseline data.
3) The population size of the pygmy hippo population in the Gola region is not known. However, a more detailed knowledge about the population size in the Gola region will help to get a more accurate estimation of the global population, to know how the Gola population ranks compared to other sites, and to reliably observe potential changes in the size of the local population.
4) Despite continuous sensitization efforts over the last decade, and an increased number of environmental education activities in recent years (especially as part of the recent pygmy hippo projects), the habitat of the pygmy hippo may be threatened in some areas around GRNP by future agricultural activities. Furthermore, poaching persists (though rarely directly targeting pygmy hippos),

especially in areas close to the Liberian border. Therefore, more environmental education activities, especially targeting community members and schools, are needed in order to assure an increased awareness about pygmy hippos, their habitat requirements and threats, and the need to conserve this unique species.

In order to address these issues and to guarantee that more detailed knowledge on the distribution and abundance of pygmy hippos is acquired in a standardized way, and that this knowledge is effectively used by the management of the GRNP and for the activities with the communities surrounding the GRNP, another Pygmy Hippo Research and Conservation project was implemented with funds provided by Basel Zoo from May 2013 to April 2014. This project focused on five activities: 1) Reconnaissance surveys along streams inside the GRNP, 2) Testing and implementation of a new survey design along focal streams, 3) Camera trap survey following a new design, 4) Dung sampling for conservation genetic analyses (for estimating population sizes) and 5) Environmental education activities. This report presents the results of this project.

Team members

The project was coordinated by Dr. Annika Hillers, the Technical Advisor for the Research & Monitoring Department of the GRNP (with support from Brima S. Turay, the Acting Superintendent). Two Research Technicians (Solomon M. Tommy and Mohamed L. Fofana) were permanently employed for the pygmy hippo project from May 2013 to April 2014. Both Research Technicians had been involved in previous pygmy hippo research and conservation activities. Jerry C. Garteh, MSc student from Njala University, wrote his MSc thesis on part of the research of this project (Garteh 2013) and thus participated and led on parts of the field work. While Mr. Tommy and Mr. Fofana engaged and sensitized communities throughout all field activities, they were supported by two environmental education specialists from the Community Development Department of the GRNP (Edward Sheriff and Mariama Kargbo) in performing more environmental education activities with communities and schools. Throughout all field activities, casual labourers were employed in communities and thus participated actively in all activities of the Pygmy Hippo Research and Conservation project. The core team of the project is shown in Figure 1.

Figure 1: The pygmy hippo core team 2013/2014, from left to right: Solomon M. Tommy (Research Technician), Jerry C. Garteh (MSc student), Mohamed L. Fofana (Research Technician)

Project Activities

1) Surveying water courses and streams inside the GRNP

Prior to this project, pygmy hippo surveys in the Gola region focused on community areas rather than the national park. Therefore, little detailed information was available about their occurrence along streams inside the protected area.

Between May 2013 and April 2014, 54 survey trips were undertaken along various parts of 24 streams. Out of these, 37 trips were reconnaissance surveys, while 17 used the newly developed survey designs (see point 2). These surveys covered a major part of streams inside the GRNP (with a focus on the central block of GRNP). A detailed list of all surveyed streams with survey dates and coordinates of start and end points for each trip are given in Appendix 1. A map of surveyed streams is shown in Figure 2.

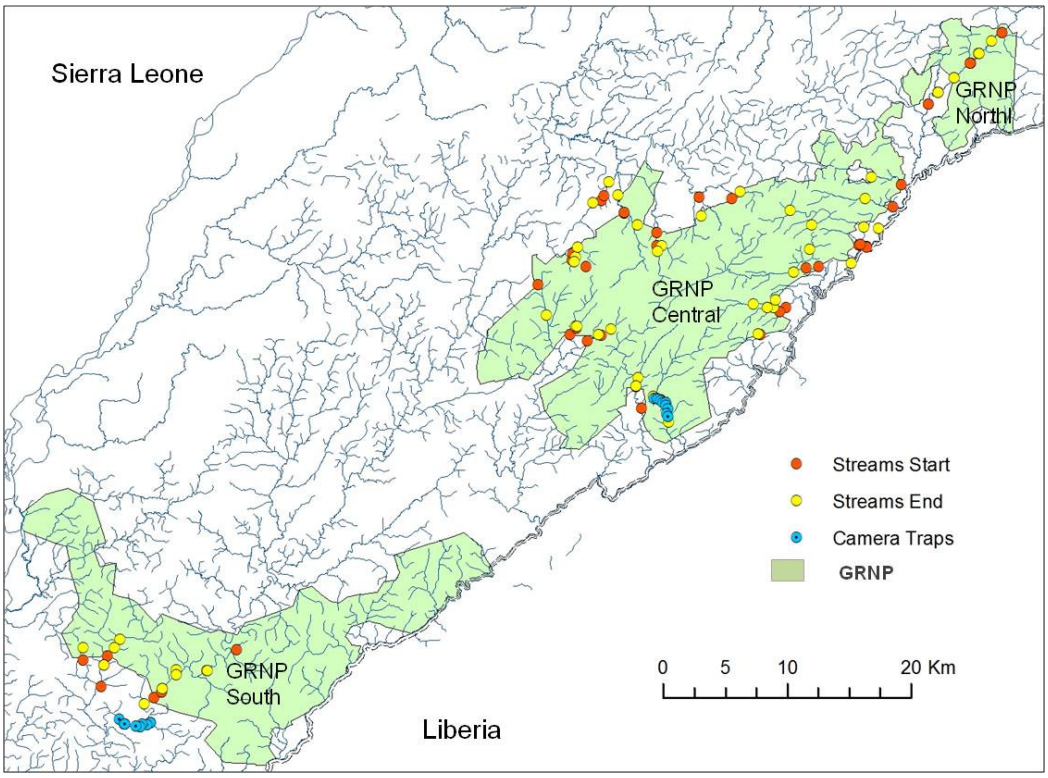

Figure 2: Overview of pygmy hippo survey activities undertaken in and around GRNP in 2013-2014. Red dots: start points for surveys along streams; yellow dots: end points for surveys along streams; blue dots: camera trap locations.

Streams were of different types and sizes, sometimes small and rocky, sometimes bigger and with swampy areas in the surrounding (Figure 3). Also the vegetation type around the streams varied from pristine primary forest to herbaceous plants in swampy areas.

Figure 3: Examples for two surveyed streams in the primary forest in Gola Central (a) and next to the village Bayama, close to Gola South (b).

During the survey trip, the team, including at least one Research Technician and one or two community members, slowly moved along streams and swamps inside the GRNP looking for pygmy hippo signs, such as footprints, trails, dung and feeding sites (Figure 4). GPS coordinates were recorded for all locations of signs. Besides the type and location of signs, different variables were recorded, such as the habitat type, the distance to the nearest stream, the width of the stream and the depth of the stream. For each GPS location, the same type of sign was only counted once for further analysis. In case footprints clearly came from different animals (e.g. a mother with a calf), this should be noted.

Figure 4: MSc student Jerry C. Garteh collecting data along stream in GRNP (a). Recorded signs were for example pygmy hippo dung that is typically sprayed on the vegetation (b) and pygmy hippo footprints (c).

2) Test and implement new survey design along focal streams

The pygmy hippo is one of the High Conservation Value species of the GRNP and therefore one of the species that will be particularly targeted by future Biodiversity Monitoring activities as defined in the Biodiversity Monitoring Plan for the Gola REDD project (Hillers & Tatum-Hume 2014). Solely using reconnaissance surveys would not allow for comparable data between different survey periods, areas and sites and the observation of changes in distribution and abundance of pygmy hippos would not be reliable. Therefore, our project aimed at developing and testing a standardized survey design that can be used for future pygmy hippo surveys.

In 2013/2014 two survey designs were developed and tested along various streams. These survey designs should allow for comparison of abundance for different sites and times (e.g. based on number of signs per surveyed km or ha). Using line transects for pygmy hippo surveys did not seem impossible and pygmy hippo signs were also observed occasionally using transects in the Gola Forest area in the past (Hillers 2013) and also were used for studying pygmy hippos in Taï National Park in Côte d'Ivoire (Roth et al. 2004). However, as the distribution of pygmy hippos observed so far was concentrated along streams, using transect methods would probably have led to overlooking many signs as transects would normally not necessarily follow the course of streams and swamps. In order to get a more comprehensive idea about the distribution of pygmy hippos and their abundance, it was therefore decided to develop a survey design that does not rely on transects, but focuses on streams and can be repeated along the same stream and at different streams in a standardized way.

The two new survey designs were developed based on the results of our survey during the first months of this project, and also taking into account results from previous surveys (Hillers & Muana 2011). Figure 5 shows the distribution of pygmy hippo signs recorded along the Makoi stream in Gola Central on 9 July 2013 as an example for distances taken into account for the development of the new survey designs. At this and also other surveyed streams, pygmy hippo signs were found within up to 100 m distance from a stream (but most of them being much closer than 100 m) and usually within less than 200 m distance from each other. Furthermore, clusters of pygmy hippo signs often did not cover more than 1.8 to 2 km along a stream, which also is a distance that can realistically be covered within one survey day. For the new survey design, it therefore was decided to aim at covering a distance of 1.8 to 2 km along one stream, focusing on 200 by 100 m plots evenly distributed along the stream.

Design A is presented in Figure 6. In this design, the distance of 1.8 km along a stream was divided into ten sections (plots), each measuring 200 by 100 m. Every second section was thoroughly surveyed by teams of two to three persons searching for pygmy hippo signs. In case pygmy hippo signs were observed in between surveyed sections, they were recorded using an opportunistic sampling data sheet that is carried by all GRNP research teams throughout all research activities and is used for any occasional records made outside of actual survey activities.

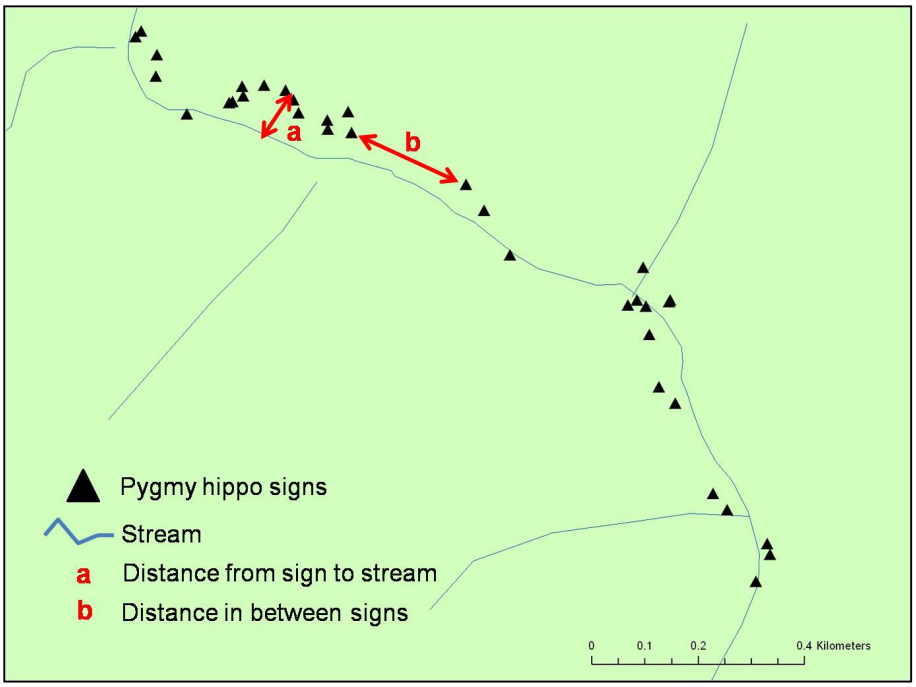

Figure 5: Pygmy hippo records along Makoi stream in Gola Central recorded on 9 July 2013 and examples for measured distances in between pygmy hippo signs and the stream and in between signs.

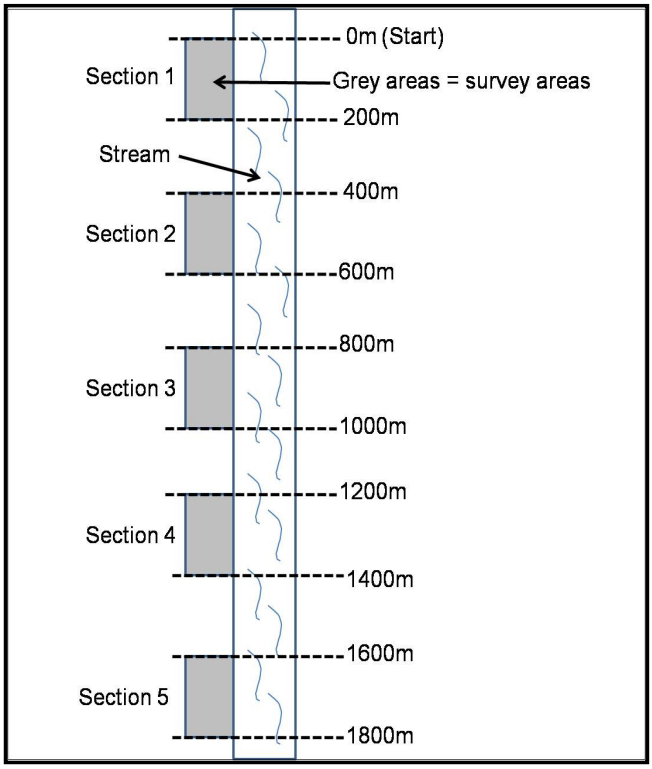

Figure 6: Newly developed survey design A, covering about 1.8 km distance along a stream. This distance was divided into ten sections of 200 by 100 m, of which every second section, thus five sections in total, was surveyed for pygmy hippo signs.

As design A covers a large area and as thoroughly searching in five 2 ha-sections within one day might be difficult, a second design (design B) was developed and tested, only focusing on five subplots within each section surveyed in design A. Design B is shown in Figure 7. Again, the same sections were used as in design A. However, within each section, only five 5 by 5 m plots in a distance of 50 m from each other were surveyed. The aim was to cover at least the same five sections as in design A, thus covering at least 25 of the 5 by 5 m plots per day. In case this method proved to be faster than design A, as a much smaller area is thoroughly surveyed, potentially a longer distance along a respective stream could be surveyed, adding more sections to the initial five. As in design A, any signs found in between surveyed plots were recorded using the opportunistic sampling data sheet.

Design A was used on 8 survey trips, design B on 9.

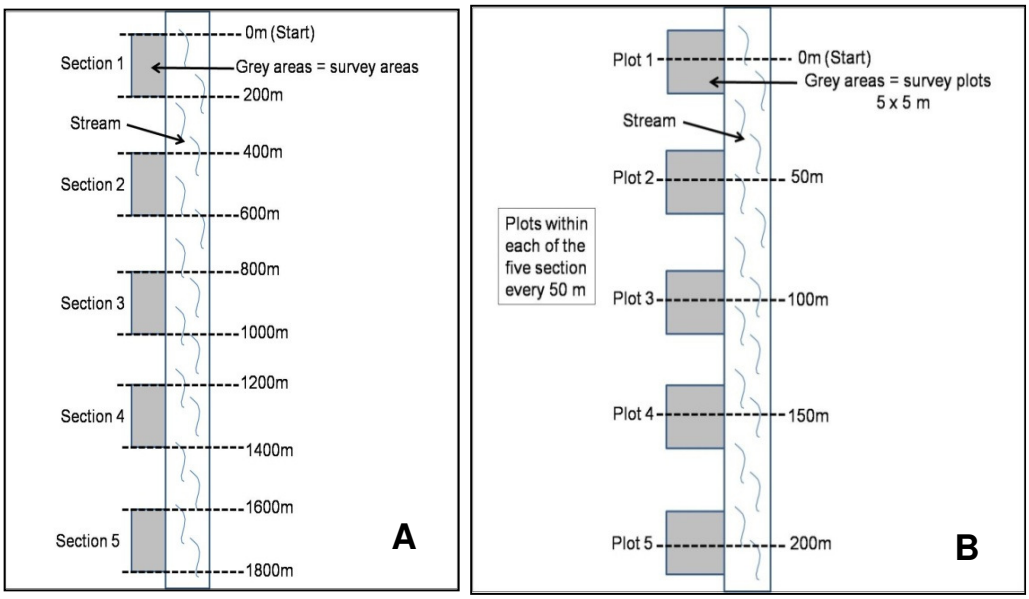

Figure 7: Newly developed survey design B, covering about 1.8 km distance along a stream. This distance was divided into ten sections of 200 by 100 m (as in design A). Within each section five plots of 5 by 5 m size were surveyed for pygmy hippo signs (B), thus covering 25 plots (625 m^2).

3) Camera trapping

Knowledge about the presence of different individuals of a species in a respective area is important for estimations of population sizes and home ranges. We therefore wished to investigate the possibility to distinguish different individuals of pygmy hippos recorded on camera traps in a defined area. Following the newly developed survey designs for the surveys along streams, also the camera trapping design focused on 200 m intervals. Within a total distance of up to 2 km along a stream, eight to ten cameras should be deployed every 200 m. However, there was some flexibility by allowing for deployment in a 100 by 200 m plot around the actual 200 m distance, in case any pygmy hippo signs (such as trails and footprints) were observed in this area. In case no pygmy hippo sign was observed, the camera trap

was placed exactly in a 200 m distance from the last camera. The new camera trapping design is shown in Figure 8.

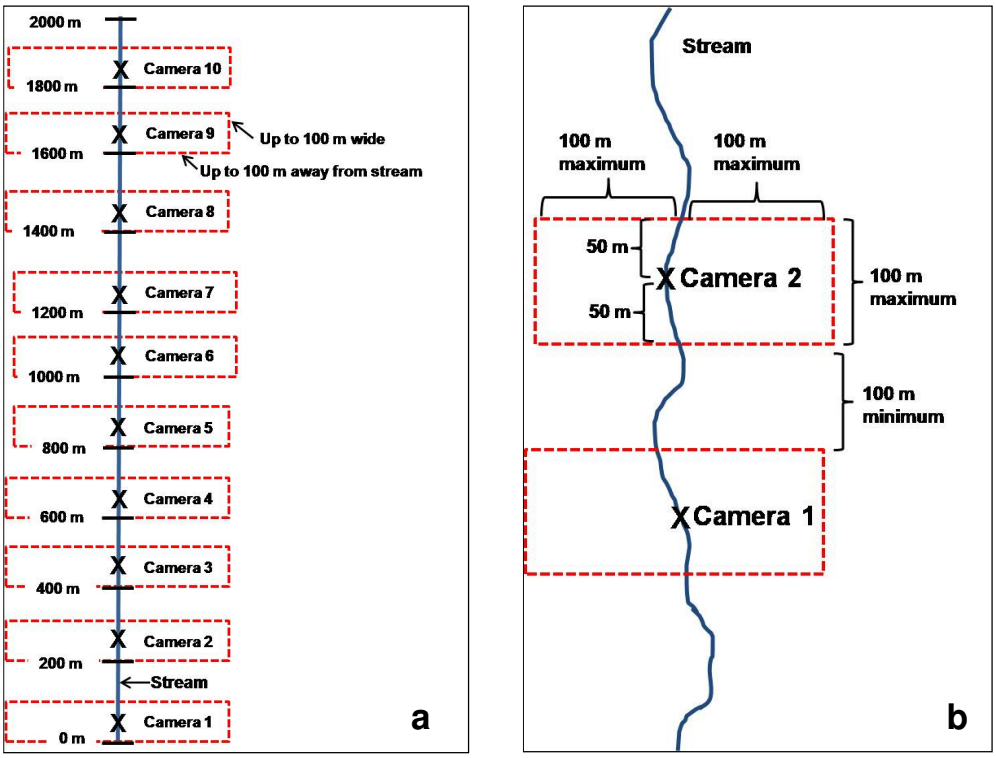

Figure 8: Location of camera trap deployment sections along a selected stretch of a survey stream (a) and location of camera trap within each section (b) in case no pygmy hippo sign was observed upon deployment (or in case the sign was located exactly in the middle of the section). In case of pygmy hippo signs observed in the section upon deployment, the camera trap was deployed close to the sign, as long as it was located within the range of the deployment section. If more than one sign were observed, the camera trap was placed close to the sign that was closer to the section center.

Two camera trap deployments were performed along two streams (Mahoi and Makoi) with 8 and 10 deployed camera traps, respectively. These streams were selected based on previously observed pygmy hippo signs. Locations of camera trap deployment are shown in Figure 1 and further details about the exact location and deployment time are given in Appendix 2. Camera traps were the model PC800 Hyperfire from Reconyx. Deployments lasted between 33 and 43 days, summing up to a total of 675 deployment days for all camera traps together

Figure 9 shows the specific survey layout for the Makoi stream in Gola Central, including exact camera trap locations and observed pygmy hippo signs.

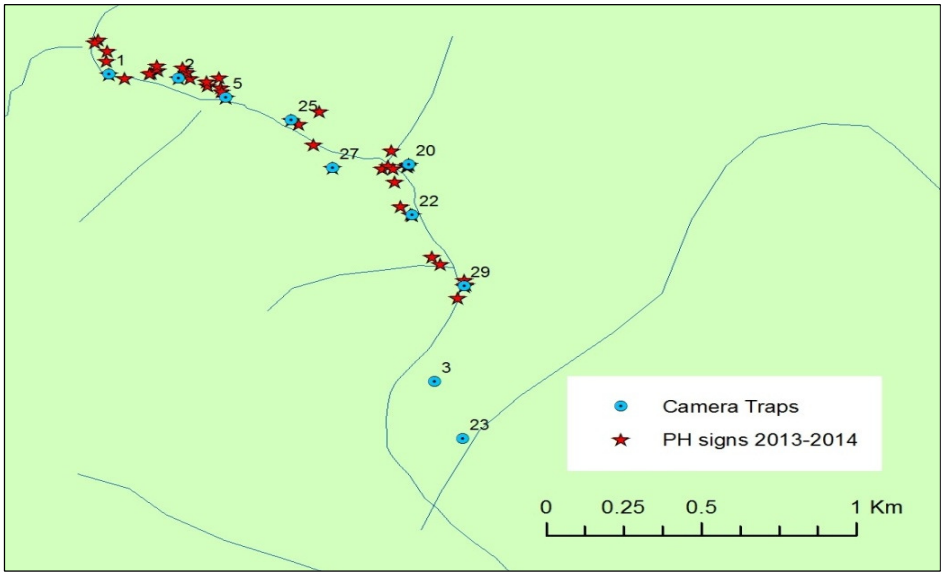

Figure 9: Specific survey layout for camera trapping in selected area along Makoi stream in Gola Central. Blue circles: camera trap deployment locations labeled with the camera trap number; red stars: observed pygmy hippo signs in the selected area.

4) Conservation genetics

The distinction of different individuals of pygmy hippos based on their dung should help to obtain some first scientifically based population estimates for the Gola region. This part of the project was planned in close collaboration with Prof. Paul O'Donoghue from the University of Chester, UK. Prof. Donoghue's lab developed genetic fingerprinting methods for pygmy hippos. Only fresh dung samples (ideally not older than 24 hours) are suitable for genetic analyses. Dung samples were collected following a sampling protocol developed by Prof. O'Donoghue in 2010. The Research Technicians were trained in the use of the protocol. They wore rubber gloves and used clean wooden spatulas to transfer fresh samples in 50ml plastic tubes with ethanol. Ideally, the samples should be stored in a freezer or fridge before being analysed.

We also planned to contribute dung samples for a regional project of the IUCN pygmy hippo specialist group.

5) Environmental education:

The GRNP has a running environmental education program implemented by the Education Team of the GRNP Community Development Department. The environmental education activities focused on community sensitisation through meetings and road shows as well as activities with schools (nature clubs and teacher trainings). Various education materials were developed in this project (see details in the results section). Furthermore, the Research Technicians engaged community members in discussions about pygmy hippos at the start of each field trip and were always accompanied by community members during their field work.

Results

1) Field surveys

In total, 81 pygmy hippo signs (footprints, trails, dung, pictures) were recorded in and around the GRNP throughout our various survey activities (reconnaissance surveys along streams, use of new survey designs, camera trapping and opportunistic data collection) from May 2013 to April 2014. A complete list of observed pygmy hippo signs with further details is given in Appendix 3. The map in Figure 10 shows the distribution of recorded signs. It also includes the signs recorded between 2008 and 2012, when surveys focused on community areas outside the GRNP, for comparison.

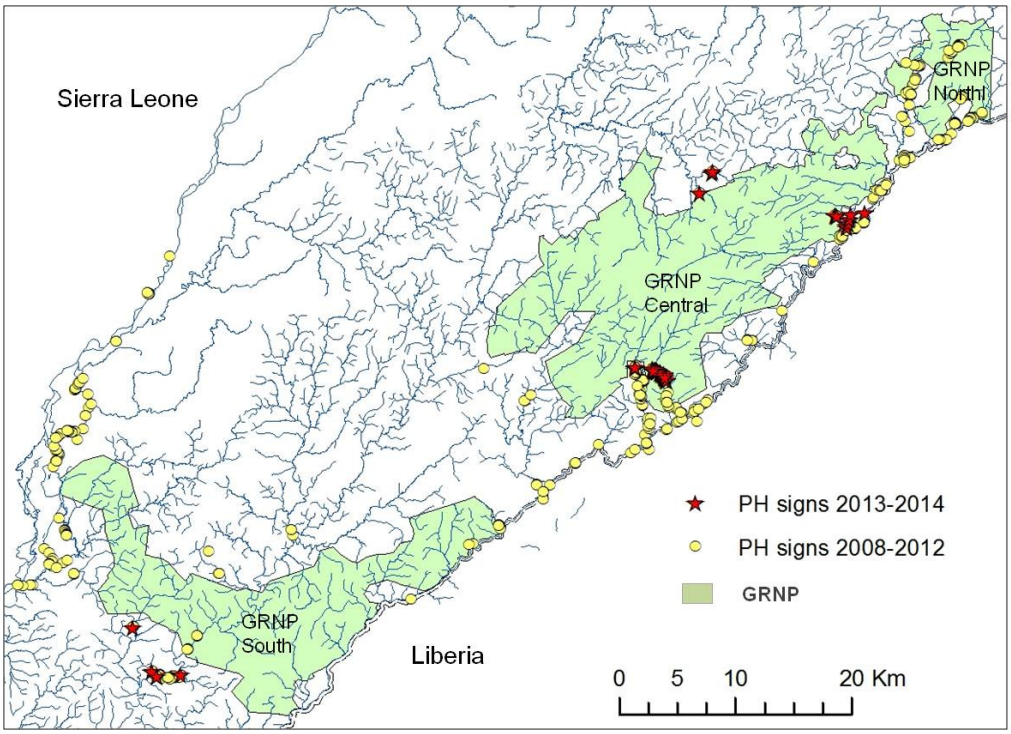

Figure 10: Distribution of pygmy hippo records in 2013-2014 (red stars) and of previous records from 2008 to 2012 (yellow dots) in and around GRNP. A detailed list of 2013-2014 records is given in Appendix 3

Pygmy hippo signs were recorded on only nine out of 54 survey trips, along six different streams, with by far the highest number of signs (33) observed along the Makoi stream at the south-eastern edge of the Gola Central block (Fig. 10). Some of the recorded signs were outside the national park as some survey trips started outside the boundary following streams running inside the GRNP.

Out of the 81 observed pygmy hippo signs only seven were recorded during the trips with new survey designs (which should be linked to the location where the designs were used, not the designs themselves). In a surface of 625 m^2 twice 1 (Yambaseh and Moro 1) and once 5 (Moro 3) signs were observed which leads to an extrapolated relative abundance of 16 and 80 signs per ha. The field team agreed that the use of design A was easier in its implementation compared to design B.

During the first camera trap deployment along the Mahoi river no pygmy hippos were recorded. However, as numerous pictures indicate, some of the camera traps were frequently visited by villagers from the adjacent community which might have caused significant disturbance, preventing pygmy hippos from coming to the respective areas during the deployment period. During the second camera trap deployment along the Makoi stream in Gola Central 13 separate events of pygmy hippo presence were captured on five out of 10 camera traps, with 167 pygmy hippo pictures in total. A detailed overview on single events is given in Table 1.

Table 1: Details on single events of pygmy hippo records made on camera traps.

Camera number	Date	Time	Number of consecutive pictures	Comments
C05	6.2.2014	7:19	18	Individual has 2 big scars on left side of body
C20	7.2.2014	19:21	5	
C29	7.2.2014	21:52	4	Individual with upper part of right ear missing; different from other individuals recorded on C29 and on other camera traps
C22	11.2.2014	23:17	3	
C22	11.2.2014	23:28	34	Likely the same individual as above
C20	16.2.2014	23:38	15	
C22	20.2.2014	23:12	15	Individual with 2 big scars (same as recorded on C05)
C29	20.2.2014	20:20	4	
C20	23.2.2014	21:07	6	Smaller than other individuals recorded on C20 (calf?)
C05	24.2.2014	5:02	18	Individual has no signs of scars on left side (different from individual from 6.2.2014)
C01	27.2.2015	00:49	21	
C20	4.3.2015	22:28	6	
C22	9.3.2014	00:05	18	

Most camera trap pictures of pygmy hippos (131 or 78.4%) were taken in the evening/early morning, i.e. between 20:20 pm and 00:49 am. The other pictures were taken in the morning (36 pictures or 21.6%) at 5:02 am and 7:19 am.

Some examples of recorded pygmy hippo pictures are given in Figure 11. Based on particular features, it was possible to distinguish at least four recorded individuals from each other. One individual, that was recorded on two different camera traps which were c. 870 m apart from each other, could be identified based on two big scars on the left front side of its body (Fig.12). Another individual was missing the top part of its right ear (Fig. 13). A third pygmy hippo, probably a calf, was smaller than other recorded individuals. And at least one individual had no visible particular features. Within the observed 1.8 km stretch along the Makoi stream we thus recorded at least four different individuals, some of them with overlapping home ranges.

Figure 11: Examples of pygmy hippo pictures recorded by camera traps in GRNP along Makoi stream.

Figure 12: Pygmy hippo with two big scars on the left side of its body recorded on two different camera traps. The two scars allowed for distinction of this individual from other individuals recorded on the camera traps.

Figure 13: Pygmy hippo with upper part of its right ear missing – a feature that made it distinguishable from other individuals recorded on the camera traps.

Habitat descriptions were available for 72 pygmy hippo signs (App. 3 and Fig. 14). The majority of signs (35 signs or 49%) were observed in swamps, mainly with open vegetation rather than being in the dense forest. The swamps were followed by 29 signs in primary forest adjacent to streams (40%). Less signs (5 signs or 7%) were found at the side of streams without detailed definition of the vegetation and in secondary forest adjacent to streams (3 signs or 4%).

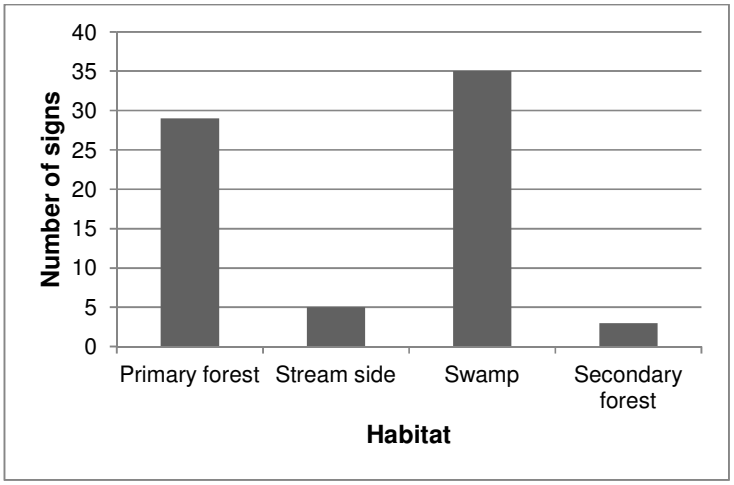

Figure 14: Number of pygmy hippo signs observed in four different habitat types.

The distance to the adjacent streams was measured for 69 pygmy hippo signs (App. 3 and Fig. 15). Based on measured distances, six different distance categories were distinguished. By far the majority of signs was found only up to 1 m from the streams (37 signs or 54%). In the following four categories, the number of signs was more evenly distributed (1.01-2 m: 9 signs or 13%; 2.01-5 m: 6 signs or 0=9%; 5.01-10 m: 10 signs or 14%; 10.01-20 m: 5 signs or 7%). Only few signs were recorded in a distance of more than 20 m away from the streams (2 signs or 3%).

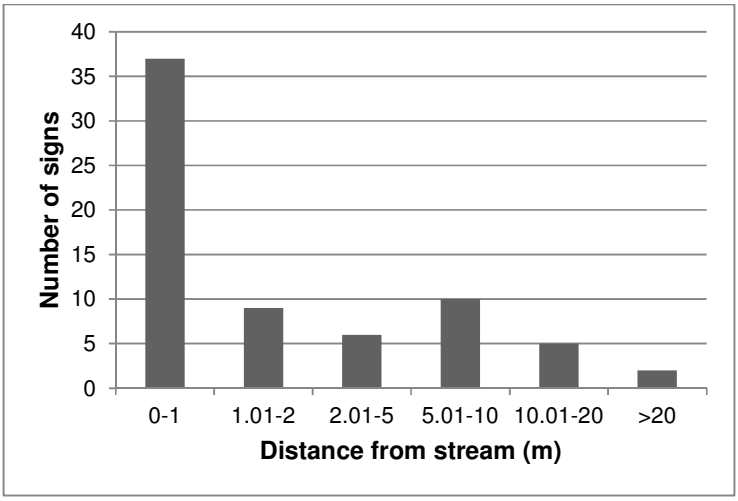

Figure 15: Number of pygmy hippo signs observed in different distances to streams.

2) Conservation genetics

During the life time of the project only three fresh dung samples could be collected (Table 2). Due to restructuring in the Forestry Division and the establishment of new export procedures (for which we were unable to get any detailed information to date, also due to the Ebola outbreak), we were not able to obtain the necessary export permits for the dung samples in 2013/2014. As the government established a new institution responsible for the protected areas in Sierra Leone, the National Protected Area Authority, which currently is again developing new procedures, we still do not know when we will be able to export our dung samples. However, the samples might not be usable anymore as during the almost 1-year long Ebola break in 2014/2015 an adequate storage of samples could not be guaranteed.

Table 2: List of collected pygmy hippo dung samples.

Date	X	Y	Altitude (m)	Age of faeces (hours)	Sample ID
9.7.2013	291254	837601	185	24	PHSMT1
10.7.2013	291900	837263	134	20	PHSMT2
1.2.2014	291653	837394	137	24	PHSMT3

5) Environmental education:

In the framework of this project various education materials were produced on pygmy hippos including conservation messages: posters (Fig.16), bumper stickers (Fig.17), a pygmy hippo information sheet (Fig. 18) and T-Shirts. These materials were distributed and discussed with communities during sensitization meetings, road shows and at the onset of field activities (Fig. 19). Furthermore, they were also used in discussions with nature clubs at schools and teacher trainings (Fig. 20), in order to include information on pygmy hippos, their threats and conservation needs into the teaching curriculum. The two Research Technicians were supported by the environmental education specialists from the Community Development Department of the GRNP, Edward Sheriff and Mariama Kargbo (Fig.16). A list of environmental education activities (community meetings and road shows) that were performed in addition to meetings at the start of each field trip is given in Appendix 4. Further information about the pygmy hippo environmental education activities of the GRNP can be found in Hillers et al. (2015).

Figure 16: Edward Sheriff and Mariama Kargbo, the environmental education specialists of the GRNP, with the pygmy hippo conservation poster that was produced during this project.

Figure 17: The two bumper stickers produced by the project.

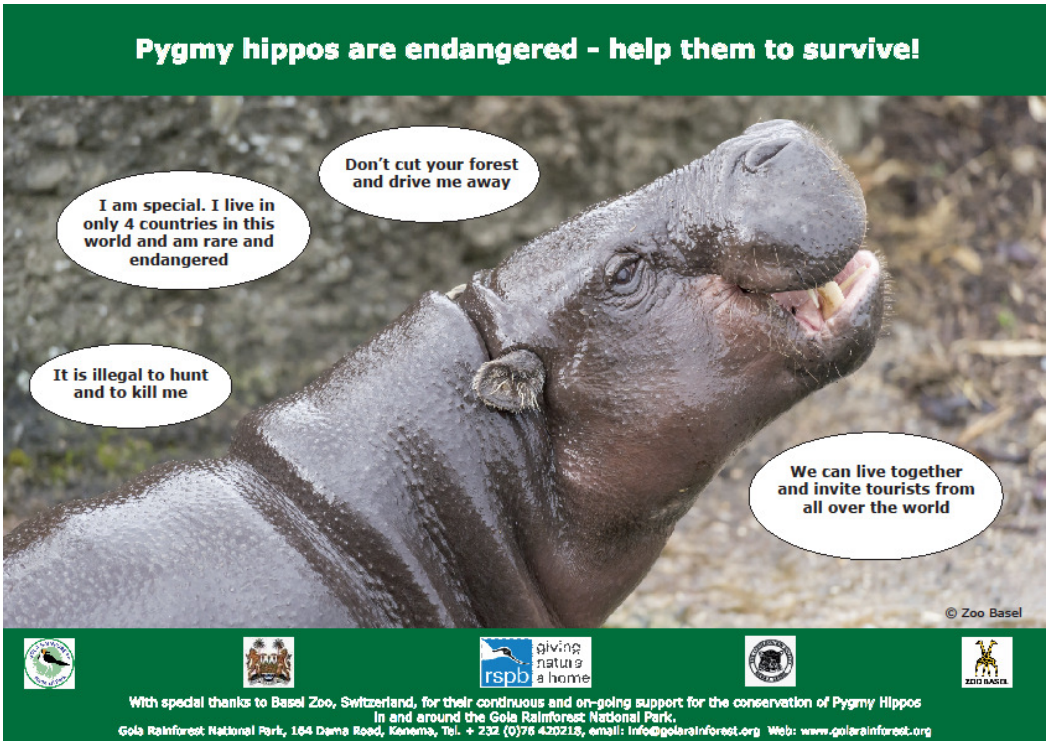

Figure 18: Front page of the pygmy hippo information sheet that was distributed and discussed in communities and schools.

Figure 19: Meeting with community members in Dambala, Nomo Chiefdom, with education materials in March 2014.

Figure 17: Teacher training including information on pygmy hippos in Zimmi, Makpele Chiefdom, in December 2013.

Discussion, recommendations and future plans

In contrary to previous pygmy hippo surveys conducted in the Gola region, the Pygmy Hippo Research and Conservation project of the GRNP in 2013 and 2014 mainly aimed at surveying the streams inside the GRNP. Two new survey designs were tested and camera traps were deployed, also following a new design. With regard to the four major issues presented in the introduction of this report, the following outputs were achieved:

1) On most of the survey trips the field surveys along the streams inside the GRNP did not record any pygmy hippo signs. It was confirmed that pygmy hippos seem to occur in only very few areas inside the national park, with a particularly high density along the Makoi stream at the south-eastern edge of the Gola Central block. Taking into account the distribution of pygmy hippos that was observed in the years 2008-2012 (Fig. 10) it becomes evident that indeed, in the Gola region pygmy hippos are mainly found in the areas along larger streams which are mainly located outside of the national park. This distribution needs to be taken into account for the GRNP activities with communities, especially for agricultural activities under the livelihood support of the Gola REDD project. For example, land-use planning for agricultural activities needs to consider the observed pygmy hippo distribution.
2) Two standardized survey designs were tested and implemented at various focal streams. The field team preferred design A, based on an easier way of implementation compared to design B. Both designs allowed for the detection of signs in a defined area, and thus for comparison of abundance of signs along different streams. Design A formed the basis for the methodology chosen for future standardized pygmy hippo surveys under the Biodiversity Monitoring program of the Gola REDD project. The Biodiversity Monitoring Plan for the Gola REDD Project (Hillers & Tatum-Hume 2014) includes detailed Standard Operating Procedures developed based on this pygmy hippo project. The data collected in 2013/2014 serve as baseline data for the future pygmy hippo surveys. The use of a standardized design will allow for direct comparison between data from different years and different sites.
3) Camera traps were deployed also following the new design. Based on the camera trap pictures, it was possible to distinguish at least four different pygmy hippo individuals within 1.8 km along a stream – which gives a first indication of the pygmy hippo population size in the Gola region (in suitable habitats). Also this new camera trap survey design is part of future pygmy hippo surveys under the Gola REDD project and the camera trap data from 2013/2014 serve as baseline data for the future. We hope the use of this method will contribute to more reliable estimates of population sizes in the future.

   The second project component aiming at the identification of pygmy hippo individuals could not be completed successfully. Only three fresh dung samples could be collected, but so far could not be exported. Thus, the samples could not be passed on to Prof. O'Donoghue at Chester University and to the IUCN specialist group, and no genetic analyses could be performed. Funds that were provided by Basel Zoo for this component of the project are still available. We hope to still perform the genetic analyses in the nearer future. However, currently it is unknown when export procedures will be in place in order to allow us to

export collected dung samples and it is probable that the old dung samples cannot be used anymore. We therefore hope to include further dung sampling into future project activities, provided the new procedure for export permits is finalized and will allow us to obtain export permits in the future.

4) Various education materials were produced and numerous community and school sensitization activities were performed in order to increase people's awareness about pygmy hippos, their threats and the urgent need to protect them. The activities and materials were welcome by the communities and schools who seemed eager to participate. However, so far it was never scientifically tested if the environmental education activities of GRNP do have a measurable impact. Future project therefore should aim at trying to assess a potential change in attitude following awareness raising activities.

The GRNP provides some important habitats for pygmy hippos, but it has been shown that the majority of pygmy hippos occurs along the rivers and larger streams outside of the protected area. In addition to the GRNP, the unprotected community land therefore is crucial for the survival of the pygmy hippo in the Gola region. The Gola REDD project includes a strong component working with communities around the national park, especially the forest edge communities that are located within the 4 km leakage belt around the GRNP. Biodiversity surveys over the last ten years have shown that besides the pygmy hippo also other threatened species are dependent on the unprotected community land in addition to the GRNP area, such as the Vulnerable bird White-necked Picathartes (*Picathartes gymnocephalus*) that forms colonies of mud nests on big rocks. Half of the known Picathartes colonies in the Gola region are in the unprotected community land, some of them being highly threatened by farming activities (Monticelli et al. 2011, Hillers 2013). Furthermore, also other threatened mammals were observed in the community areas around the national park, such as Jentink's duikers, sooty mangabeys, western chimpanzees etc. (Hillers 2013). It therefore seems necessary to include even more community-based conservation activities into the work of the GRNP, in addition to the ongoing environmental education activities.

The GRNP plans to introduce a community youth volunteer conservation programme that is targeting unemployed youth in the forest edge communities. It is especially the unemployed youth that is prone to engage into illegal activities that are threatening the integrity of the forest habitat and its wildlife, such as mining, logging and poaching. The community youth volunteers will be trained in wildlife monitoring and community sensitization in order to implement monthly monitoring and sensitiation activities, if funds sufficient funds are available especially focusing on the two most threatened species in the community areas of the Gola region, the pygmy hippo and the White-necked Picathartes. The observation of monthly surveys will be reported back to their respective communities and the community volunteers will also participate in environmental education activities in the schools of their communities. The volunteers thus will become active ambassadors for the conservation of pygmy hippos (and other threatened species that profit from an increased awareness). The community volunteers will come from focal communities that were identified as being crucial for the survival of pygmy hippos (and others for the White-necked Picathartes)

in the Gola region. If funds are available, additional education materials will be produced, focusing on the threatened species of GRNP, especially the pygmy hippo (and the White-necked Picathartes).

In order to assess the impact of the community youth volunteer conservation programme, the GRNP plans to administer questionnaires to assess the attitude towards and knowledge about pygmy hippos (and the White-necked Picathartes) in communities with and without conservation volunteers at the start and after 1 or 2 years of the programme. For the pygmy hippo component of the programme, we hope to train community volunteers also in the collection of dung samples in order to still obtain samples for the conservation genetic analyses that could not be completed in 2013/2014.

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We also thank all project partners of the GRNP, i.e. the Forestry Division of the Ministry of Agriculture, Forestry and Food Security, the Conservation Society of Sierra Leone and the Royal Society for the Protection of Birds. Especially the various departments of the GRNP, i.e. Management, Administration, Finances, Community Development and Research & Monitoring contributed to the successful implementation of this project.
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Appendix 1

List of surveyed streams with survey dates, times, start and end coordinates and number of observed pygmy hippo signs. Coordinates are in UTM 29 N.

Name of Stream	Date	Start time	End time	Start coordinates		End coordinates		No. of observed pygmy hippo signs
				X	Y	X	Y	
Lewei	15.05.2013	09:08	na	307860	849824	304048	851479	4
Lewei	15.05.2013	09:08	na	307860	849824	302324	852654	0
Kpoyewa	16.05.2013	08:15	na	310621	852912	308381	853601	0
Kpoyewa	16.05.2013	10:28	na	311262	854710	308874	855337	0
Mogbai	16.05.2013	12:14	na	304595	848113	302564	847649	0
Wekwa	18.05.2013	13:40	na	303619	847967	303889	849525	0
Hojoyea (Branch)	30.05.2013	08:33	13:02	284681	848601	284984	848875	0
Tekuyei	30.05.2013	10:03	14:40	281948	846628	282610	844193	0
Weisugbu	31.05.2013	08:12	16:22	285784	848083	285156	849693	0
Hojoyea (Main)	07.06.2013	07:49	14:30	284767	849161	284835	848491	0
Wowei (Upper)	08.06.2013	10:45	16:55	288873	852429	289977	851459	0
Wulor (Main stream)	08.06.2013	10:30	12:40	291551	850877	291952	849793	0
Wulor (branch)	09.06.2013	11:23	11:56	291548	849758	291602	849350	0
Wowei (Lower)	09.06.2013	10:46	14:40	288920	852505	288376	853904	0
Mamawa	11.06.2013	09:34	17:03	294952	853731	295098	852211	1
Mamawa	11.06.2013	13:46	15:10	297577	853576	298281	854141	0
Kwadi	07.07.2013	10:34	14:14	289855	838389	290008	839107	0
Kwadi	07.07.2013	10:54	15:35	290291	836678	289828	838454	0
Makoi (Upper)	09.07.2013	10:38	15:15	291848	837332	291254	837601	15
Makoi (Lower)	09.07.2013	09:02	17:38	292082	837087	292482	835535	14
Makoi (Lower)	10.07.2013	10:33	13:21	291832	837315	292275	837020	4
Kondehua	26.07.2013	12:31	15:22	285943	842123	286841	842577	0
Koyei (Wayeihun)	26.07.2013	13:26	16:19	284505	842583	284970	843250	0
Koyei (tributary)	27.07.2013	12:29	15:49	284999	843134	285090	843283	0
Kondehua 2	27.07.2013	12:49	16:14	287042	842573	287850	843061	0
Wegbua 1	19.08.2013	12:02	14:45	301972	844763	300948	844771	0
Wegbua 2	20.08.2013	12:51	15:32	300957	844774	301142	845409	0
Wegbua 3	21.08.2013	11:25	15:23	301436	844432	300480	844772	0
Wegbua 4	22.08.2013	12:24	16:12	300480	844789	299312	845055	0
Weisei	22.08.2013	14:33	14:58	299865	842598	299745	842636	0
Mahoi	12.10.2013	11:34	17:09	250904	813234	251608	814004	0

Name of Stream	Date	Start time	End time	Start coordinates		End coordinates		No. of observed pygmy hippo signs
				X	Y	X	Y	
Mahoi	13.10.2013	09:11	16:02	251609	814013	252711	815165	0
Mahoi	14.10.2013	11:38	17:25	257606	817120	255206	815439	0
Mahoi 4	15.10.2013	09:27	16:53	255199	815448	252684	815478	0
Nyeiyea	17.10.2013	09:38	15:36	245182	816315	245170	817318	0
Yambaseh	18.10.2013	09:53	17:02	247144	816630	248185	817983	0
Mahoi	30.10.2013	11:00	12:49	250622	811236	248564	811129	4
Wobia	09.11.2013	11:26	13:14	287021	853432	287636	854973	0
Moro	18.11.2013	09:00	13:47	308453	849701	309446	851196	1
Moro	19.11.2013	09:26	11:35	308462	849690	307221	848399	0
Moro	20.11.2013	09:31	14:27	307987	849886	308232	851274	5
Weisukpu	09.12.2013	11:06	14:11	287253	853819	286368	853237	0
Makpoi	14.12.2013	10:09	16:05	313455	861224	314264	862164	0
Makpoi	15.12.2013	08:00	18:45	313458	861219	314243	862158	0
Makpoi	16.12.2013	11:39	15:56	314263	862162	315572	863375	0
Makpoi	17.12.2013	10:41	15:53	314264	862163	315556	863370	0
Upper Makpoi 1	9.1.2014	9:48	12:15	316868	864515	317549	865342	0
Upper Makpoi	10.1.2014	10:12	16:11	316861	864522	317515	865298	0
Upper Makpoi 2	11.1.2014	10:54	13:07	319429	867013	318602	866309	0
Yambaseh 1	11.1.2014	9:00	15:00	246621	814142	246854	815884	1
Upper Makpoi 2	12.1.2014	10:51	13:46	319420	867018	317549	865342	0
Yambaseh 2	12.1.2014	10:57	15:34	246853	815895	247699	817281	0
Mahoi 1	13.1.2014	12:40	16:50	251532	813733	250114	812731	0
Mahoi 2	14.1.2014	11:28	15:27	251518	813699	252705	815116	0

Appendix 2

List of deployed camera traps with deployment and collection dates and times, coordinates and type of observed signs of pygmy hippos at deployment (if any). Coordinates are in UTM 29 N.

Camera No.	Deployment date	Deployment time	Collection date	Collection time	Coordinates		Sign used
					X	Y	
30	30.10.2013	11:40	02.12.2013	15:06	250622	811236	Trail
4	30.10.2013	12:24	02.12.2013	14:35	250358	811067	None
2	30.10.2013	13:35	02.12.2013	13:37	249974	811103	Trail
28	30.10.2013	14:18	02.12.2013	13:02	249801	810876	None
29	30.10.2013	14:58	02.12.2013	12:09	249476	810950	None
1	31.10.2013	11:40	03.12.2013	12:00	248104	811528	Trail
5	31.10.2013	12:36	03.12.2013	12:48	248496	811121	Trail
23	31.10.2013	13:02	03.12.2013	13:16	248564	811129	Trail
1	1.2.2014	16:39	14.3.2014	13:55	291289	837461	Trail
2	1.2.2014	17:06	16.3.2015	11:26	291512	837447	Footprint
5	1.2.2014	17:41	14.3.2014	12:56	291666	837369	Trail
25	1.2.2014	18:15	14.3.2014	12:11	291876	837279	Trail
27	2.2.2014	13:20	14.3.2014	11:11	292011	837086	Trail
20	2.2.2014	13:49	14.3.2014	17:08	292255	837099	Trail
22	2.2.2014	14:22	15.3.2014	9:27	292267	836896	Trail
29	2.2.2014	15:13	16.3.2014	12:20	292433	836612	Trail
3	2.2.2014	16:20	15.3.2014	11:46	292338	836226	None
23	2.2.2014	16:25	15.3.2014	12:10	292428	835998	None

Appendix 3

List of pygmy hippo signs observed throughout surveys along streams, using recce and newly developed methods, and throughout opportunistic sampling, and camera trapping, with dates and coordinates. Coordinates are in UTM 29 N.

Date	Type of sign	Coordinates		Habitat	Distance from Stream (m)	Sampling method
		X	Y			
15.05.2013	Footprints	306938	850819	Forest along stream	1.08	Reconnaissance
15.05.2013	Footprints	307061	850751	Forest along stream	1.02	Reconnaissance
15.05.2013	Trail	307113	850789	Forest along stream	0.50	Reconnaissance
15.05.2013	Trail	307081	850776	Forest along stream	0.70	Reconnaissance
11.06.2013	Footprints	295259	852726	Stream side	2.8	Reconnaissance
11.06.2013	Trail	296355	854440			Opportunistic
11.06.2013	Footprints	296403	854606			Opportunistic
07.07.2013	Trail	289730	837688			Opportunistic
07.07.2013	Footprints	289715	837721			Opportunistic
09.07.2013	Trail	291650	837410	Swamp along stream	0.5	Reconnaissance
09.07.2013	Trail	291644	837449	Swamp along stream	0.5	Reconnaissance
09.07.2013	Trail	291606	837416	Swamp along stream	1	Reconnaissance
09.07.2013	Trail	291550	837447	Swamp along stream	1	Reconnaissance
09.07.2013	Trail	291541	837471	Swamp along stream	0.5	Reconnaissance
09.07.2013	Trail	291526	837489	Swamp along stream	0.5	Reconnaissance
09.07.2013	Trail	291446	837479	Swamp along stream	1	Reconnaissance
09.07.2013	Trail	291426	837468	Swamp along stream	1	Reconnaissance
09.07.2013	Trail	291420	837466	Swamp along stream	0.5	Reconnaissance
09.07.2013	Feeding site	291444	837497	Swamp along stream	1	Reconnaissance

Date	Type of sign	Coordinates		Habitat	Distance from Stream (m)	Sampling method
		X	Y			
09.07.2013	Trail	291340	837445	Swamp along stream	1	Reconnaissance
09.07.2013	Trail	291281	837516	Swamp along stream	1	Reconnaissance
09.07.2013	Trail	291283	837556	Swamp along stream	1	Reconnaissance
09.07.2013	Fresh dung	291254	837601	Swamp, open vegetation	4	Reconnaissance
09.07.2013	Trail	291243	837590	Swamp, open vegetation	1	Reconnaissance
09.07.2013	Footprints	292249	837091	Swamp, open vegetation	0.8	Reconnaissance
09.07.2013	Trail	292251	837094	Swamp, open vegetation	0.6	Reconnaissance
09.07.2013	Trail	292260	836899	Swamp, open vegetation	0	Reconnaissance
09.07.2013	Footprints	292171	837084	Swamp, open vegetation	1.6	Reconnaissance
09.07.2013	Footprints	292188	837094	Swamp, open vegetation	1.4	Reconnaissance
09.07.2013	Footprints	292229	836930	Swamp, open vegetation	1.8	Reconnaissance
09.07.2013	Footprints	292211	837029	Swamp, open vegetation	1.8	Reconnaissance
09.07.2013	Trail	292331	836729	Swamp, open vegetation	1.2	Reconnaissance
09.07.2013	Footprints	292205	837082	Swamp, open vegetation	1.2	Reconnaissance
09.07.2013	Trail	292200	837155	Swamp, open vegetation	1.6	Reconnaissance
09.07.2013	Trail	292439	836615	Swamp, open vegetation	1.2	Reconnaissance
09.07.2013	Footprints	292358	836698	Swamp, open vegetation	0.7	Reconnaissance
09.07.2013	Trail	292433	836635	Swamp, open vegetation	0	Reconnaissance
09.07.2013	Footprints	292412	836563	Swamp, open vegetation	0.1	Reconnaissance
10.07.2013	Trail	291604	837433	Swamp	1	Reconnaissance

Date	Type of sign	Coordinates		Habitat	Distance from Stream (m)	Sampling method
		X	Y			
10.07.2013	Trail	291966	837312	Stream side	5	Reconnaissance
10.07.2013	Dung	291900	837263	Stream side	1	Reconnaissance
10.07.2013	Footprints	291949	837179	Stream side	1	Reconnaissance
30.10.2013	Footprints	250622	811236	Primary forest	10	Reconnaissance/ Camera trap deployment
30.10.2013	Trail	248104	811528	Primary forest	40	Reconnaissance
30.10.2013	Trail	248496	811121	Primary forest	40	Reconnaissance
30.10.2013	Trail	248564	811129	Primary forest	20	Reconnaissance
31.10.2013	Trail	248104	811528	Primary forest		Camera trap deployment
31.10.2013	Trail	248496	811121	Old sec. forest		Camera trap deployment
31.10.2013	Trail	248564	811129	Old sec. forest	10	Camera trap deployment
18.11.2013	Footprints	309523	851037	River	0	New design
20.11.2013	Footprints	307987	849886	Swamp	0	New design
20.11.2013	Footprints	307964	849773	Swamp	0	New design
20.11.2013	Footprints	308105	850114	Swamp	0	New design
20.11.2013	Trail	308151	850461	Swamp	0	New design
20.11.2013	Footprints	308151	850461	Swamp	0	New design
20.11.2013	Trail	308156	850442			Opportunistic
20.11.2013	Dung	308167	850509			Opportunistic
20.11.2013	Footprints	308167	850509			Opportunistic
20.11.2013	Footprints	308334	850922			Opportunistic
11.01.2014	Footprints	246481	815311	Second. forest		New design
1.2.2014	Trail	291289	837461	Primary forest	6	Camera trap deployment
1.2.2014	Footprints	291512	837447	Primary forest	7	Camera trap deployment
1.2.2014	Trail	291666	837369	Primary forest	19.01	Camera trap deployment
1.2.2014	Trail	291876	837279	Primary forest	7	Camera trap deployment
1.2.2014	Dung	291653	837394			Opportunistic/Dung collection
2.2.2014	Trail	292011	837086	Primary forest	0.9	Camera trap deployment

Date	Type of sign	Coordinates		Habitat	Distance from Stream (m)	Sampling method
		X	Y			
2.2.2014	Trail	292255	837099	Primary forest	6.08	Camera trap deployment
2.2.2014	Trail	292267	836896	Primary forest	0.9	Camera trap deployment
2.2.2014	Trail	292433	836612	Primary forest	5	Camera trap deployment
6.2.2014	Picture	291666	837369	Primary forest	19.01	Camera trap
7.2.2014	Picture	292255	837099	Primary forest	6.08	Camera trap
7.2.2014	Picture	292433	836612	Primary forest	5	Camera trap
11.2.2014	Picture	292267	836896	Primary forest	0.9	Camera trap
16.2.2014	Picture	292255	837099	Primary forest	6.08	Camera trap
20.2.2014	Picture	292267	836896	Primary forest	0.9	Camera trap
20.2.2014	Picture	292433	836612	Primary forest	5	Camera trap
23.2.2014	Picture	292255	837099	Primary forest	6.08	Camera trap
24.2.2014	Picture	291666	837369	Primary forest	19.01	Camera trap
27.2.2015	Picture	291289	837461	Primary forest	6	Camera trap
4.3.2015	Picture	292255	837099	Primary forest	6.08	Camera trap
9.3.2014	Picture	292267	836896	Primary forest	0.9	Camera trap

Appendix 4

Overview of Environmental Education activities with focus in pygmy hippo sensitisation

Date	Village	Chiefdom	Activity
18.9.2013	Joru	Gaura	Teacher training for school nature clubs
17.10.2013	Njama	Malema	Community sensitisation
18.10.2013	Bumpeh	Malema	Community sensitisation
19.10.2013	Madina	Malema	Community sensitisation
20.10.2013	Jojoima	Malema	Community sensitisation
9.12.2013	Zimmi	Makpele	Teacher training for school nature clubs
24.2.2014	Borgbuabu	Koya	Community sensitisation/Road show
28.2.2014	Belebu	Tunkia	Community sensitisation/Road show
3.3.2014	Faama	Nomo	Community sensitisation/Road show
5.3.2014	Zimmi	Makpele	Community sensitisation/Road show
7.3.2014	Potoru	Barrie	Community sensitisation/Road show
9.3.2014	Jojoima	Malema	Community sensitisation/Road show
27.3.2014	Faama	Nomo	Community sensitisation
28.3.2014	Waima	Nomo	Community sensitisation
30.3.2014	Dambala	Nomo	Community sensitisation