Final Evaluation Report

Your Details	
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Project Title	Millipede diversity, distribution and conservation assessment in the Douala-Edea Wildlife Reserve, Cameroon
Application ID	29713-2
Grant Amount	£5,762
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Date of this Report	07/02/2021

1. Indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.

Objective	Not achieved	Partially achieved	Fully achieved	Comments
Millipede habitat characterization				We have recorded and characterised millipede habitats in Douala-Edea Wildlife Reserve. Overall, five main habitats were recorded: primary forests, secondary forests, swamp forests (mangrove), agroforests and open meadows (cultivated farms and fallows). Primary forests were characterised by the presence of large tree species such as *Coula edulis*, *Coula gabonensis, Baillonella toxisperma,* and *Lophira alata*. The undergrowth giving the appearance of a climax formation. Secondary forest is a forest that has been disturbed due to human actions. The forests of this reserve have been affected by oil exploitation around the tail board. Characteristic species of the forest disturbance are *Macaranga assas* and *Mussanga cecropioides*. Swamp forests are found in the vicinity of rivers. They are not very diversified, have clear undergrowth and only a few trees form the canopy, while the agroforests were mainly made up of palm trees (*Elaeis guineensis*), cocoa trees (*Theobroma cacao*) and rubber (*Hevea brasiliensis*). The open meadows (fallows and crop fields) consisted of *Chromolaena odorata*, maize, cassava, plantains and macabo.
Characterization and evaluation of human pressure and threat on the forests and millipede species				Various pressures on natural ecosystems by local populations living in and around the Douala-Edea Wildlife Reserve, actually transformed into a national park were assessed. These pressures ranging from the clear-cuts to the anarchic exploitation of forest tree species such as *Lophira alata*, *Pycnanthus angolensis* and *Baillonella toxisperma*. Highly intensive agricultural activities with destructive practices, such as slash-and-burn, were recorded. These

				practices have negative effects on the soil fauna in general and particularly millipedes which are generally vulnerable.
Knowledge of people about the importance and use of millipedes in and around the study areas				People of the littoral forest of Cameroon know about millipedes and use them for several purposes. Among persons interviewed during this study, we noted that millipede species are sustainable indicators of the degree of transformation of forest ecosystems. Millipede species seem to dominate farmlands and fallows. These animals are usually used as indicators of the seasonal change. Certain species of millipedes are used by the local population for the treatment of certain conditions or infections. Populations living in and around the Douala-Edea Wildlife Reserve reported that millipedes have very little importance. The only information with strong involvement in millipede conservation processes are some traditional taboos and proscriptions. Collected specimens were usually found under leaf litter and dead wood in decompositions.
Millipede species richness, diversity, distribution, and community structure in accordance with all ecosystem types prospected in the study area.				In total 36 millipede species belonging to 22 genera and nine families were identified from 799 individuals identified. Chelodesmidae was the most represented in terms of species richness (eight species). Next to this family were Oxydesmidae and Spirostreptidae (six species respectively), followed by Pyrgodesmidae (five species) and Odontopygidae (four species). Pachybolidae, Stemmiulidae and Trichopolydesmidae were represented by two species respectively, while Cyptodesmidae was monospecific. The most species-rich habitat was primary forest (24 species), followed by mangrove (17 species), secondary forest (13 species), open meadows (11 species), while agroforest was the less species rich habitat with only four species. Differences in species richness for all habitat types of combination were highly significant in pairwise comparison ($p<0.0001$). The primary forest, mangrove and secondary forest showed the highest values of diversity indices ($H'= 2.86$; $E= 0.73$ for primary forest ;

				H'= 2.55, E= 0.76 for mangrove and H'= 2.31, E= 0.77 for secondary forest), while the agroforest and open meadows showed the lowest (H'= 0.97, E= 0.66 for agroforest and H'= 1.45, E= 0.39 for open meadows). Based on Bray-Curtis distance, the cluster analysis revealed that the secondary forest, the primary forest, mangrove and agroforest formed a cluster that was distinct from open meadows. However, between both clusters the Bray-Curtis distance is too short suggesting a very weak dissimilarity among habitat types. The highest millipede abundance was observed in open vegetation (334 specimens, representing 41.80% of all millipedes collected). Next to this habitat were primary forest (215 specimens, representing 26.91% of all the specimens collected) and mangrove forest (179 specimens, representing 22.40% of all the specimens collected), whereas the secondary forest (49 specimens, representing 6.13% of all specimens collected) and agroforest (22 specimens, representing 2.75% of all specimens collected) showed the lowest millipede abundance. In general, differences in millipede abundance among habitat types were highly significant ($H = 20.05$; $P < 0.0001$). Three species namely *Trichochalepuncus* sp. (25.91%), *Kartinikus colonus* (9.39%) and *Urodesmus cornutus* (8.01%) were the most abundance during the study period.

2. Please explain any unforeseen difficulties that arose during the project and how these were tackled.

No major problem was encountered during the realisation of this project. The only difficulty arose was the organisation of meetings with the presence of all stakeholders (i.e., local authorities and all the people living at each village around and in the Douala-Edea wildlife reserve) in order to sensitise or educate them on the importance of millipedes and the necessity of their conservation in natural ecosystem due to of Covid 19 health situation. Nevertheless, by applying the distant and other the barrier measures this part of the study was finally conducted. Also, the fieldwork started 1 month later than expected due to the slowness of bank fund transfer.

3. Briefly describe the three most important outcomes of your project.

- Millipede habitat characterization

We have recorded and characterised millipede habitats in Douala-Edea Wildlife Reserve. Overall, five main habitats were recorded, primary forests, secondary forests, swamp forest (mangrove), agroforest and open meadows (cultivated farms and fallows). Primary forests were characterised by the presence of large trees species such as *Coula edulis*, *Coula gabonensis, Baillonella toxisperma,* and *Lophira alata*. The undergrowth giving the appearance of a climax formation. Secondary forests have been disturbed due to human actions. The forests of this reserve have been affected by oil exploration around the tail board. Characteristic species of the forest disturbance are *Macaranga assas* and *Mussanga cecropioides*. Swamp forests are found in the vicinity of rivers. They were not very diversified, have clear undergrowth and only a few trees form the canopy. The agroforests were mainly made up of palm trees and cocoa trees. The open meadows (fallows and crop fields) were consisted of *Chromolaena odorata*, maize, cassava, plantains and macabo. Collected specimens were usually found under leaf litter and dead wood in decompositions.

-Characterisation and evaluation of human pressure and threat on the forests and millipede species

Various pressures on natural ecosystems by the local populations living in and around the Douala-Edea Wildlife Reserve, actually transformed into a national park were assessed. These pressures ranging from the clear-cuts to the anarchic exploitation of forest species as *Lophira alata*, *Pycnanthus angolensis* and *Baillonella toxisperma*. Highly intensive agricultural activities with destructive practices, such as slash-and-burn, were noted. These practices have negative effects on the soil fauna in general and particularly millipedes which are generally vulnerable. We also noted an establishment of industrial companies such as SAFACAM which exploits rubber and SOCAPAL which exploits the palm oil around the reserve. The activities of these companies require the use of a huge amount of chemicals that are generally harmful to the soil fauna in general and millipedes in particular. It is also apparent from this study that populations living in and around the Douala-Edéa Wildlife Reserve are mainly engaged in the exploitation of clam shells. This activity seems to be harmful for the millipede insofar as the shells extracted from the Sanaga River are spread and burned over a large expanse of land which could considerably affect the survival of millipede species with a very slow dispersal ability. Indeed, during this research, we noted, a large number of dead specimens of millipede in a large stretch of land after the slash and burn. The major threats that face millipedes in the plantation around the Douala-Edea Wildlife Reserve of Cameroon are bushfire, agricultural practices, clear-cuts for the production of coal, use of chemicals in cocoa and palm oil plantations, but also artisanal timber exploitation.

-Knowledge of people about the importance and use of millipedes in and around the study areas

People of the littoral forest of Cameroon known millipede and use them for several purposes. Among 150 persons interviewed during this study, we noted that millipede species are sustainable indicators of the degree of transformation of forest ecosystems. Over 82% of those interviewed reported that some of these millipede species seem to be dominant in farmlands and fallows. Others reported the empirical use of millipedes as indicators of the season change. The treatment of certain conditions or infections such as haemorrhoids and certain incurable wounds are done with certain species of millipedes. Millipede, like most invertebrates, have very little importance for the populations of the littoral region of Cameroon and those living in and around the Douala-Edea Wildlife Reserve in particular. The only information with strong involvement in millipede conservation processes are some traditional taboos and prescriptions. In fact, the millipede arouses great fear among the populations interviewed, which is very often beneficial for the conservation of these species. Nevertheless, some people systematically kill millipedes on the pretext that they bring bad luck. This perception of millipede suggested the fundamental problem of poor knowledge of these animals by the local populations and thus constitutes a considerable limit to their conservation in the natural ecosystem.

-Millipede species richness, diversity, distribution, and community structure in accordance with all ecosystem types prospected in the study area.

- **Millipede species richness and distribution**

In total 36 millipede species belonging to 22 genera and nine families were identified from 799 individuals collected. Chelodesmidae was the most represented in terms of species richness (eight species). Next to this family were Oxydesmidae and Spirostreptidae (six species respectively), followed by Pyrgodesmidae (five species) and Odontopygidae (four species). Pachybolidae, Stemmiulidae and Trichopolydesmidae were represented by two species respectively, while Cyptodesmidae was monospecific. In primary and secondary forests, the millipede community was dominated by Chelodesmidae (five species respectively). In mangrove, the community was dominated by Chelodesmidae and Oxydesmidae (four species respectively). While in open meadows (cultivated farms and fallows), the community was dominated by Pyrgodesmidae (fiv e species).

The most species rich habitat was primary forest (24 species), followed by mangrove (17 species), secondary forest (13 species), open meadows (11 species), while agroforest was the less species rich habitat with only four species. Differences in species richness for all habitat types of combination were highly significant in pairwise comparison ($p<0.0001$). *Kartinicus colonus* was widely distributed as it occurred in all habitat types. *Paracordyloporus trisolabris*, *Coenobothrus bipartitus*, *Laciniogonus* sp., *Heptadesmus granulosus*, *Spirostreptus pancratius*, *Urotropis carinatus*, *Urotropis* sp., *Stemmiullus nigricollis*, *Stemmiullus* sp. and *Hemispheroparia integratus* were restricted to primary forest. Similarly, *Diaphorodesmus dorcicornis* and *Systodesmus kribi* occurred exclusively in secondary forest. *Afolabina sanguinicornis, Diaphorodesmoides* sp., *Coromus barumbi* and *Treptogonostreptus intricatus* occurred exclusively in mangrove forest whereas *Monachodesmus*

longicaudatus, Monachodesmus sp.1, *Monachodesmus* sp.2 and *Udodesmus* sp. were restricted to open meadows.

- **Millipede species diversity among habitat types**

The primary forest, mangrove and secondary forest showed the highest values of diversity indices (H'= 2.86 ; E= 0.73 for primary forest ; H'= 2.55, E= 0.76 for mangrove and H'= 2.31, E= 0.77 for secondary forest), while the agroforest and open meadows showed the lowest (H'= 0.97, E= 0.66 for agroforest and H'= 1.45, E= 0.39 for open meadows). Pairwise comparisons revealed highly significant differences among habitat types. In agroforest, mangrove, secondary forest and primary forest, the Pielou Eveness was near 1, suggesting a very high homogeneity of the communities in those habitat types. Table 2 in appendix also showed in general as well as in primary forest, secondary forest and mangrove, a negligible dominance of a particular species, and thus a very high species diversity of the communities. While in agroforest and open meadow, there is a strong dominance of a particular species, and thus a very low species diversity of the communities. The non-parametric estimator Chao1 revealed that in general, 36 species over 37 have been collected suggesting that only one rare species has not been sampled. Furthermore, in primary forest, 24 species over 26 have been collected suggesting that two rare species have not been collected. In secondary forest, 13 species over 15 have been recorded, suggesting that two rare species have not been collected. Whereas in mangrove, agroforest and open meadows, almost all species have been collected.

Based on Bray-Curtis distance, the cluster analysis revealed that the secondary forest, the primary forest mangrove and agroforest formed a cluster that was distinct from open meadows. Moreover, the secondary forest, the primary forest and mangrove also formed a cluster that was distinct from agroforest. However, between both clusters the Bray-Curtis distance is too short suggesting a very weak dissimilarity among habitat types.

- **Variation in millipede species abundance among habitat types**

Overall, 799 specimens were collected during the study period. The highest millipede abundance was observed in open vegetations (334 specimens, representing 41.80% of all millipedes collected). Next to this habitat were primary forest (215 specimens, representing 26.91% of all the specimens collected) and mangrove forest (179 specimens, representing 22.40% of all the specimens collected). Whereas the secondary forest (49 specimens, representing 6.13% of all specimens collected) and agroforest (22 specimens, representing 2.75% of all specimens collected) showed the less millipede abundance. In general, differences of millipede abundance among habitat types were highly significant ($H = 20.05$; $P < 0.0001$).

Three species namely *Trichochalepuncus* sp. (25.91%), *Kartinikus colonus* (9.39%) and *Urodesmus cornutus* (8.01%) were the most abundant during the study period (Table 1, annexe). In primary forest, *Kartinikus colonus* 32(4.01%) and *Pelmatojulus tectus* 21(2.63%) were also the most abundant species, while *Paracordyloporus trisolabris, Hemisphaeroparia mouanko, Hemispheroparia integratus* 1(0.13% respectively) and *Spirostreptus pancratius* 2(0.25%) were the less abundant species. In secondary forest, *Systodesmus kribi and Telodeiopus cananiculatus* 8(1.00% respectively) were the most abundant species while *Coromus* sp., *Paracordyloporus* sp. 1(0.13%

respectively), *Kyphopyge granulosa* and *Coromus vitatus* 2(0.25 respectively) were the less abundant species. In mangrove forest, *Afolabina sanguinicornis* 41(5.13%) and *Kartinikus colonus* 20(2.50%) were numerically dominant species while *Kyphopyge granulosa and Systodesmus valdaui* 3(0.38%) respectively, were the less represented species. In agroforest, *Kartinikus colonus* 15(1.88%) was the numerically abundant species while *Trichochalepuncus* sp. and *Urodesmus cornutus* 2(0.25%) respectively, were the less abundant species. In open vegetation, *Trichochalepuncus* sp. 204(25.53%) was numerically dominant species while *Kartinikus colonus* 2(0.25%) was the less abundant. When considering seasons, the abundance varied with no significant difference between seasons. However, millipedes were more abundant during the dry season than during the rainy season. Moreover, millipede communities of both dry and rainy seasons varied with highly significant differences among habitat types.

4. Briefly describe the involvement of local communities and how they have benefitted from the project.

Local communities are an important partner for us, since the beginning of the project, we contacted local communities and youths from our study sites and since then we are working very closely with them. They have been trained in the routine methodology to collect data for conservation activities. Combined with action from local authorities, those persons can now help to monitor the long-term impact of this project from the study site. One member of the community called Gnoxe was particularly interested by the project and was working with us during all the project period in the field. He learned during this period all the methods to collect and preserve millipedes and also other tools about the work in research and education. Gnoxe was fascinated by the work on this invertebrate group and how to be carried out a research and decided to return to school since he has stopped several years ago to learn more about animal and forest conservation. We are exploring the options to keep working together.

5. Are there any plans to continue this work?

There is a plan to continue this work. We will pursue our research on behalf of nature conservation in protected areas using millipede as indicator model of biodiversity survey. We also plan to determine the IUCN conservation status, the distribution, the size of population and all the threat that face giant endemic millipede species (*Pelmatojulus tectus* (Cook, 1897), *Pelmatojulus exisus* (Cook, 1897) and *Treptogonostreptus intricatus* (voges, 1878)) recorded during this study in Douala-Edea wildlife reserve. From the results of this project, practical indicators of millipede can be proposed to assess soil quality and land management impacts. The next step will be to validate the used of millipede as bioindicators in various ecosystems in Afrotropical region and mainly in Congo Basin region.

6. How do you plan to share the results of your work with others?

Some results and image of this project field work was used during my PhD presentation in June 2020 at the University of Yaounde 1. A final version of my thesis is deposited in libraries for public use. We are also preparing scientific papers where

we are going to describe our main findings about the species we are studying. The paper will be made available to Rufford Foundation and scientists through different congress, meetings with biologists, ecologists and conservation institutions with several presentations.

7. Timescale: Over what period was the grant used? How does this compare to the anticipated or actual length of the project?

This project was initially planned to take place within a period of 12 months from December 2019 to November 2020. Due to the fact that we received the funds at the end of January 2020, the study was finely conducted between February 2020 and January 2021. The grant was used in the same length. The order of the activities has not been changed and all of them was accomplished.

8. Budget: Provide a breakdown of budgeted versus actual expenditure and the reasons for any differences. All figures should be in £ sterling, indicating the local exchange rate used. It is important that you retain the management accounts and all paid invoices relating to the project for at least 2 years as these may be required for inspection at our discretion.

Item	Budgeted Amount	Actual Amount	Difference	Comments
Hand held GPS	£274	£274		No change made
Meeting and sensitization of local population	£355	£355		No change made
Communications (Internet and local calls)	£195	£195		No change made
Accommodation- food	£1176	£1260	+£84	We planned to spend 3.5£/ person for nutrition. Due to the price inflation in because of the Covid 19 pandemic situation, we rather spend 3.75£/person.
Field guides and Assistant per-diem bag	£1218	£1218		No change made
Tents (3 persons) and Sleeping mat	£195	£195		No change made
Fields and laboratory supplies	£284	£240	-£44	Supplies were more expensive than originally budgeted. The rest of money helped us to cover Food/per diems cost and paying some of our guides and porters.
Digital camera	£250		-£250	I received a

				Digital camera from Dr Didier VANDERSPIEGEL (Royal Museum for Central Africa, Tervuren, Belgium) during his field trip in Cameroon
Maps, repairs & first aid kit	£175	£175		As initially Budgeted
Travel in and out study area (From Yaoundé to the study sites (Yaounde-Edea-Douala)	£1320	£1644	+£324	Transport costs costs were more than originally budgeted. Urban and interurban transport costs in Cameroon vary widely. We spend £15/day/per site instead of £14 as budgeted
Field visit (contacts organization, administrative formalities)	£125	£125		No change made
Miscellaneous	£274	£274		No change made. These unforeseen expenses was to complete the financial deficit necessary and sometimes to pay some local formers and other people in order to create the cordial environment with our interlocutors. This was quite important to be understood by those persons.
Totals	£5762	£5792	-£30	Notes to budget: The currency used in Cameroon is XAF (CFA franc). The exchange rate is 1 GPB= 727 XAF, please note that the exchange rate fluctuates constantly. **Exchange rate:** £ 1= 727XAF

9. Looking ahead, what do you feel are the important next steps?

With the supplement experience acquired during this project implementation, it's important to promote and enhance invertebrate survey in protected area of the Littoral region forest of Cameroon. According to the importance of forest health and stability on the survival of millipede, the most important steps should be: (1) publishing the results and making them available to local authority in charge of wildlife protection in Cameroon; (2) continuing to sharing and divulgate the obtained results in different scientific events and teaching activities; (3) sustain the educational programme to ensure villagers and politicians understand the

importance of protecting these animals, creating a spirit of conservation throughout the community; and (4) looking for other funds to continue research on millipede diversity and conservation in Cameroon, particularly on some vulnerable, rare and threatened millipede species such as *Pelmatojulus tectus* (Cook, 1897), *Pelmatojulus exisus* (Cook, 1897) and *Treptogonostreptus intricatus* (voges, 1878) all representing giant, endemic and threatened species recording during this project. It is important to establish the size of their populations, their distribution range and their conservation status according to IUCN criteria during the next step.

10. Did you use The Rufford Foundation logo in any materials produced in relation to this project? Did the Foundation receive any publicity during the course of your work?

Yes, we used the RF logo on materials we produced such as some leaflets and posters presented during workshops at the Department of Animal Biology and Physiology of the Faculty of Science of the University of Yaoundé I and during national scientific conferences recently held at the Université of Yaoundé 1, in December 2020. The RF logo was also use during my PhD defense in June 2020 at the University of Yaoundé 1. I also used the Rufford Foundation logo in my several official documents using during the implementation of this project. The logo will be also used soon to divulgate our results at the upcoming international congress of Myriapodology. The Rufford Foundation is acknowledged in scientific publication in preparation on millipede diversity and conservation in the Douala-Edea Wildfive Reserve.

11. Please provide a full list of all the members of your team and briefly what was their role in the project.

Armand Richard NZOKO FIEMAPONG as principal investigator of the project, implemented the field work (collected millipede species in the study site and conduct the survey on the perception and threat that face millipede species in Douala-Edea Wildlife Reserve within the local population), the species identification and reporting.

Pr. Henrik ENGOFF Confirm some of our species identification and provided us a useful advising and comments during all of the implementation of the project.

Miss. Jeanne YETCHOM, PhD candidate University of Douala as Research assistant, participated in all field activities but also the report production.
Pr. Sévilor KEKEUNOU University of Yaoundé 1 help us in some ecological interpretation of our results and in data analysis.

Mr. Alphonse SAME and **Mr. Gnoxe MOUKOKO** was our field guides helping us to carry some material and sometime participated to local people sensitization in local language.

12. Any other comments?

We are extremely grateful to The Rufford Foundation for granting us such opportunity to contribute to species conservation in Cameroon through the Rufford Small Grant. Without this financial support we could never have accomplished what we did on these target species in the Littoral region of Cameroon. Although consideration of this important component of fauna, they have historically been neglected in conservation planning and management, substantial progress with surveys, systematics and bioindication means that it is now feasible to incorporate them into biodiversity monitoring activities programme in protected areas. There is a lot of work remaining to be done in this eco-region of Cameroon and we need to work with more people, and this is the reason why we are trying to involve more of them in the project under different levels of involvement. However, the challenge has always been to obtain funding for research in invertebrate taxonomy and conservation including millipede. We are especially grateful to Jane Raymond for all her tireless efforts. We thank the traditional chiefs and all local people leaving in and around the Douala-Edea wildfive reserve for making the project successful.

Mangrove forest

Open vegetation

Secondary forest

Field survey

Systodesmus valdaui

Aporodesmus gabonicus

Telodeinopus cannaniculatus

Odontostreptus sp.

Pelmatojulus excisus

Spirostreptus pancratius

Urotropis carinatus

Coromus sp.

Picture taking during the PhD defence of Armand Richard NZOKO FIEMAPONG at University of Yaounde 1 in Jun 2020

Slide showing all the partners who supported my PhD thesis study