The Rufford Foundation
Final Report

Congratulations on the completion of your project that was supported by The Rufford Foundation.

We ask all grant recipients to complete a Final Report Form that helps us to gauge the success of our grant giving. The Final Report must be sent in **word format** and not PDF format or any other format. We understand that projects often do not follow the predicted course but knowledge of your experiences is valuable to us and others who may be undertaking similar work. Please be as honest as you can in answering the questions – remember that negative experiences are just as valuable as positive ones if they help others to learn from them.

Please complete the form in English and be as clear and concise as you can. Please note that the information may be edited for clarity. We will ask for further information if required. If you have any other materials produced by the project, particularly a few relevant photographs, please send these to us separately.

Please submit your final report to jane@rufford.org.

Thank you for your help.

Josh Cole, Grants Director

Grant Recipient Details	
Your name	MBENOUN MASSE Paul Serge
Project title	Diversity, ecology and conservation of mountain millipedes in centre Cameroon
RSG reference	20814-2
Reporting period	December 2016 – December 2017
Amount of grant	£4996
Your email address	Masseserge8@gmail.com
Date of this report	December 09th, 2017

1. Please 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
1)determine the species diversity and community structure of millipedes				A total of 1071 millipede individuals were recorded and identified to 52 species from four orders representing 11 families and 32 genera. Polydesmida was the most abundant and species-rich order (49.11%; 28 species) followed by Spirostrptida (33.42%; 20 species), Spirobolida (15.77%; 3 species) and Stemmiulida (1.68%; species). The species-rich family was Spirostreptidae (15 species) followed by Chelodesmidae (seven species), Odontopygidae, Gomphodesmidae and Cryptodesmidae with five species each. The most frequent species were *Aporodesmus gabonicus* (29.42% of occurrences) followed by *Kartinikus colonus* (13.75%).
2) Effect of elevational gradients on millipede species richness and abundance				Along the elevational gradients, millipede richness first increased from 34 to 36 species at low altitude (820 - 920 m) and reached a peak, and then decreased from 34 to 32 at high altitude (1020-1156m). The relative abundance pattern of two most abundant millipede species varied significantly between different altitudes. *Aporodesmus gabonicus* abundance decreased from 14.1 to 13.3% (820-1020 m), increased and reached a maximum of 49.74 % (1020-1120m), and decreased to 15.5% (>1120m). With *Kartinicus colonus*, the relative abundance first increased and reached a mid-elevational peak (1020m), then decreased at high altitude.
3)point out the potential threatened habitats and				From the mountain foot to the top, various anthropogenic activities

species				strongly influence the patterns of species richness and abundance. At low altitudes (820 -920 m), the millipede species richness was low (34 species) and the landscape is mainly rural and consists of patches of agricultural lands, and villages. At mid-altitudes (920 -1020 m), species richness (36 species) was higher than at low altitudes. The increase in species at his elevation corresponds to two ecotones: the transition between the deciduous forest and montane forest. At high altitudes (1020 -1156 m), species richness decreases (32 species) as a result of the increased frequency of cooler temperatures and continuously wet substrate combined with reduced solar radiation and smaller area.
4)document the present status of millipedes in these vulnerable habitats				We recorded overall 52 species of millipedes in the study area with many species new to science. Some species are restricted in anthropised area such as *Anisodesmus erytropus* and *Thelydesmus* sp. whereas *Tymbodesmus* sp.1, *Tymbodesmus* sp.2. and *Spirostreptus laevis* were found only in forest patches at upper altitudes. Interestingly, although some species are restricted in particular elevation, others are found in all elevations (e.g. *Amblybolus laevicilis, Aporodesmus gabonicus, Odontostreptus sjostedti*). These species seem to be extremely vulnerable to human activities and any disturbance to the environment as their occurrence and abundance increase with the decreasing of human disturbance at upper altitudes.

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

Mountainous areas in Cameroon are sacred places of many traditional and religious practices. Several villagers gather and pray on statutes, sacred trees and shrines that

are installed there. As a result, access to this environment is often restricted to certain insiders who have been fortified. To get there, we met the village chief and after explaining the aim of our research and its importance, he kindly gave us a local guide and a porter.

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

The study of diversity, ecology and conservation of upland millipedes in Centre Region of Cameroon achieved several significant outcomes. However, the most three important outcomes are as follows:

- The mount kala is very rich in regard to millipede diversity with 52 species belonging to 11 families and 32 genera. Species richness recorded in this mount was higher than species richness recorded one year ago in lowland area in southern Cameroon rainforest (27 species) (Mbenoun et al. 2017). We recorded many species new to science and seem to be restricted to this mountain between 1020 and 1156 m, above sea level (*Tymbodesmus* sp.2, *Tymbodesmus* sp.3, *Coromus* sp., *Scolodesmus* sp.2.). These species are presently being described at the Laboratory of Zoology.

- The elevational gradient affects patterns of distribution, abundance and diversity of millipede species. Density and abundance per species increased exponentially with increase in elevation (820-920 m), peak at mid-elevation (1020 m) and decrease at higher altitudes (1156 m). For instance, *Aporodesmus gabonicus* abundance decreased from 14.1 to 13.3% (820-1020 m), increased and reached a maximum of 49.74 % (1020-1120m), and decreased to 15.5% (>1120m). For other species such as *Kartinicus colonus* and *Amblybolus laevicolis*, the relative abundance reached a mid-elevational peak (920-1020m) and then decreased at high altitude. Otherwise, some millipedes are restricted to particular elevations while others are widely spread on elevational gradients and are more tolerate in their habitat requirements (*Kartitinus colonus*, *Gymnostreptus* sp., *Odontostreptus sjostedti*, *Pelmatojulus excicus, Thrinculus laevicolis*). Three species were unique between 820 and 920 m a.s.l (*Oxydesmidae Gen. sp., Scolodesmus grallator*, *Tymbodesmus falcatus*) , three between 920 and 1020 m asl (*Paracordyloporus* sp. , *Pyrgodesmidae* Gen. sp., *Spirostreptus laevis),* three between 1020 and 1120 m a.s.l *(Coromus* sp., *Scolodesmus* sp.2, *Urotropis propinqua),* and four at the summit (1156 m asl) (*Odontopyge bipartita, Onychostreptus assiniensis, Spirostreptus amandus, Tymbodesmus* sp.2.).

- This study also demonstrated a negative relationship between anthropisation and millipede richness between 820 and 1020, where anthropised zones currently represent the largest part of available area. At these elevations, we recorded a low species richness (34 species) compared to mid-elevation (36 species), while only 32 species were recorded at higher elevation. Density per species increased exponentially with increase in elevation, so at higher altitudes the decrease in species richness was compensated by an increase in worker density for each species, a pattern named as ''density

compensation''. In this study, we showed that the density of millipedes increased in the order of 920 m (44 /m^2), 1020m (78/m^2), and 1156 m (212/m^2) elevations. In sum, Millipede species richness increases with decreasing of human disturbance along elevational gradient. This result is consistent with other studies that investigated the impact of human disturbances on millipede diversity along disturbance gradients, carried out at the Campo Ma'an National Park, Cameroon (Mbenoun et al. 2017).

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

The study was carried out with the help of the local communities who assisted in all stages of the survey. Local populations were used as field guide or porters throughout the project. They were trained in scientific monitoring techniques (use a GPS device, how to conduct transects, collect millipedes species, conservation of specimens). During the surveys, they understood the importance to conduct such studies in order to protect their local forest resources from disturbance by using millipedes as bio indicators of habitat change.

5. Are there any plans to continue this work?

Yes. As I mentioned in the first Rufford Small Grant, the overall objective of my project is to enhance a checklist of the millipedes in Cameroon. I have already gathered results from lowland diversity during the first grant and currently gathered results from upland area in centre region of Cameroon. I will continue investigating the distribution and diversity of millipedes in others mountains areas around the centre region , because I noticed during my research that high altitudes areas, particularly some upland urban forest patches, are hotspots of biodiversity and endemism, but they are neglected in research works and threatened by anthropogenic activities mainly urbanisation. Due to high human pressure observed in these vulnerable habitats, I will also intend to identify critical sites that provide permanent refuge for endangered species for the long-term protection through the creation of protected area.

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

We have recently presented the findings of the project at the oral session at the 24th Annual Conferences of the Cameroon Biosciences Society organised from November 28th to 2nd December 2017 in Buea, Cameroon. In addition, to reach out to a wider audience outside the scientific community, I have produced and disseminated the posters to local field guides, porters and village chiefs living around the mountainous areas.

I will also submit the following manuscript for publication in a peer reviewed journal during the next months:

- Effects of human disturbance and elevational gradient on millipede diversity and abundance at mount Kala, Cameroon.

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

The grant provided for the study was used for a period of 1 year (December 2016 - December 2017). We conducted a monthly survey (1 week /zone x 4 zones x 1 month) at different altitudes zones (820, 920, 1020, 1156m a.s.l) at mount kala.

8. Budget: Please 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.

Item	Budgeted Amount(£)	Actual Amount (£)	Difference	Comments
Hydro-Thermometer	156	120	+36	This device was lower than budgeted
Alcohol, formaldehyde, glycerol	120	120	0	
Travel in and out study site	2400	2400	0	
Food	1440	1440	0	
Local guide cost	480	616	-136	Local guide and porters required more money than budgeted
Internet, phone, fax, photocopying	150	150	0	
Miscellaneous (5%)	250	250	0	
Total	4996	5096	-100	The exchange rate was £1 equalling to 752, 49 frs CFA at the date of transaction instead of 754, 23frs CFA as budgeted.

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

Millipedes (Diplopoda) are among the most numerically abundant creatures in the nature after Insecta and Arachnida, but have received much less attention than other soil invertebrates. Study of the diversity of poorly known taxonomic group in different ecosystems (lowland, coastland, upland, savannah, dessert, and mangrove) will be crucial to enhance a checklist of the millipedes in Cameroon. I will continue investigating in upland urban forest patches around the centre region where no study has to date carried on mountain millipedes so as to document the diversity of encountered species and preserve these vulnerable ecosystems threaten by urbanisation (increasing of human population size) and other any disturbance. This study demonstrated a negative relationship between anthropisation and millipede richness at lower altitudes, where anthropized zones currently represent the largest part of available area; therefore education projects through community awareness campaign involving local population living around the mountains areas

and graduate students will educate and enlighten the people on the ecological importance of millipede as bio indicators of environmental changes, primary destructors of plant debris in the forest and play crucial role in soil formation processes. Furthermore, awareness campaign will be a strong motivation for the local communities to be actively involved in the management of their local forest resources.

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

Yes. I used the logo in one presentation of the project at the oral session at the 24th Annual Conferences of the Cameroon Biosciences Society organized from November 28 to December 02, in Buea, Cameroon. I also used the logo in posters of the project to sensibilize local populaton and students about the effect of human disturbance on millipede assemblages.

11. Any other comments?

I sincerely thank RSG for supporting the second study of Cameroonian millipedes carried out in high altitudes areas in centre region of Cameroon. Further, the RSGF help will be duly acknowledged in all public talks or papers regarding this subject.
Thanks to RSG (1st and 2nd Grant), three articles have been published in a peer review journal and one master student has been trained.

Scientific production:

P.S. Mbenoun Masse, A. R. Nzoko Fiemapong, D. VandenSpiegel, S.I. Golovatch. **2017**. Diversity and distribution of millipedes (Diplopoda) in the Campo Ma'an National, southern Cameroon. *African Journal of Ecology*. Doi: 10.111/aje.12418.

P.S. Mbenoun Masse, Yde, Ndankeu, Y.P. **2017**. Distribution patterns and diversity of leaf litter and soil-dwelling arthropods in a lowland rainforest in southern Cameroon. *Journal of Biodiversity and Environmental Sciences*. 10: 181-189.

Armand Richard Nzoko Fiemapong, **Paul Serge Mbenoun Masse,** Joseph Lebel Tamesse, Sergei Ilyich Golovatch and Didier VandenSpiegel, **2017.** The millipede genus *Stemmiulus* Gervais, 1844 in Cameroon, with descriptions of three new species (Diplopoda, Stemmiulida, Stemmiulidae). *Zookeys*. 708: 11-23.

Master student trained:

Samuel Didier MAKON. Diversité et écologie des myriapodes sur le mont Kala (Région du Centre- Cameroun). Master II with thesis (in preparation), Laboratory of Zoology, University of Yaoundé I.

Coromus sp.

Odontostreptus sjostedti