Project Update: June 2020

From our work on millipede diversity, distribution and conservation assessment in the Douala-Edea Wildlife Reserve, Cameroon, we obtained the following results.

Milipede species richness

Overall, 25 millipede species have been recorded. These species belonged to nine families and 19 genera. Among the nine families and for all types of vegetation, Odontopygydae was numerically dominant. The most represented family in terms of genera and species richness was Chelodesmidae (four genera and 6 species) (Table 1). In cultivated farms and fallow areas, the community was dominated by Odontopygydae. In palm oil plantations, the community was dominated by Spirostreptidae, whereas in swamp forests the community was dominated by Chelodesmidae. In primary forest, the community was dominated by Spirostreptidae and Odontopygydae. No family was observed as dominant in secondary forest. The most species rich habitat was swamp forest (17 species), followed by primary forest (14 species), while fallow areas, palm oil plantations, secondary forest and cultivated farms showed the lowest species richness (seven, four, four and two species respectively).

Variation in millipede species abundance among vegetation types

Among the 444 (17.76±5.04) individuals collected over the study period, 164 (6.56±4.41) were observed in fallow areas, 158 (6.32±1.81) in swamp forest, 79 (3.16±0.96) in primary forest, 22 (0.88±0.61) in palm oil plantations, 11 (0.44±0.32) in secondary forest, and 10 (0.40±0.33) in cultivated farms (Tables 1). Differences among types of vegetation were highly significant ($H=61.63$; $p<0.0001$) (Table 1). Significant variations were also observed among combined vegetation types ($p<0.0001$) using pairwise comparisons, with the exception of cultivated farms and fallow ares, palm oil plantations and secondary forest, swamp forest and primary forest, primary forest and fallow areas, secondary forest and fallow areas and palm oil plantations and primary forest. Four species (*Trichochalopuncus* sp. 119 (13.79%), *Kartinicus colonus* 53(13.34%), *Urodesmus cornutus* 42 (7.85%) and *Pelmatojulus tectus* 30 (7.67%)) were the most abundant (Table 1). In the fallow areas, the most abundant species were *Trichochalopuncus* sp. 108 (24.32%) and *Urodesmus cornutus* 28 (6.31%). In the swamp forest, *Afolobina sanguinicornis* 41 (9.23%) and *Kartinikus colonus* 20 (4.50%) were most abundant. In the primary forest, the most abundant species were *Kartinikus colonus* 16 (3.60%), *Laciniogonus* sp. 14 (3.15%) and *Urotropus carinatus* 12 (2.70%). In the palm oil plantations, the most abundant species was *Kartinikus colonus* with 15 (3.38%). In the cultivated farms and secondary forest, *Trichochalopuncus* sp and *Telodeiopus canuculatus* were respectively the most abundant species (8 (1.80%) each). (Table 1).

Table 1. Absolute and relative abundance (in %) of each Millipede species in different vegetation types in Cameroon.

Order	Family	Species	Farmland	Fallow	Palm oil plantation	Swamp forest	Secondary forest	Primary forest	Total
Polydesmida	Chelodesmidae	*Afolabina sanguinicornis*	0	0	0	41 (9.23)	0	0	41 (9.23)
		Diaphorodesmoides sp.	0	0	0	5 (1.13)	0	0	5 (1.13)
		Diaphorodesmus dorcicornis	0	0	0	0	1 (0.23)	0	1 (0.23)
	C	*Paracordyloporus porati*	0	3 (0.68)	0	6 (1.35)	0	0	9 (2.03)
		Paracordyloporus trisolabris	0	0	0	0	0	1 (0.23)	1 (0.23)
		Kyphopyge granulosa	0	0	0	1 (0.23)	0	0	1 (0.23)
	Pyrgodesmidae	*Urodesmus cornutus*	0	28 (6.31)	2 (0.45)	9 (2.03)	0	3 (0.68)	42 (9.46)
	Cryptodesmidae	*Aporodesmus gabonicus*	0	0	0	17 (3.83)	0	3 (0.68)	20 (4.50)
	Oxydesmidae	*Coromus* sp.	2 (0.45)	2 (0.45)	0	2 (0.45)	1 (0.23)	1 (0.23)	8 (1.80)
		Coromus barumbi	0	0	0	14 (3.15)	0	0	14 (3.15)
		Coromus vitatus	0	0	0	4 (0.90)	0	3 (0.68)	7(1.58)
		Systodesmus valdaui	0	0	0	3 (0.68)	0	4 (0.90)	7 (1.58)
	Trichopolydesmidae	*Hemisphaeroparia mouanko*	0	5 (1.13)	3 (0.68)	5 (1.13)	0	1 (0.23)	14 (3.15)

Spirostreptida	Odontopygydae	*Coenobothrus bipartitus*	0	0	0	0	0	3 (0.68)	3 (0.68)
		Coenobothrus detruncatus	0	0	0	9 (2.03)	0	0	9 (2.03)
		Laciniogonus sp.	0	0	0	0	0	14 (3.15)	14 (3.15)
		Trichochalepuncus sp.	8 (1.80)	108 (24.32)	2 (0.45)	0	1 (0.23)	0	119 (26.80)
	Spirostreptidae	*Spirostreptus pancratius*	0	0	0	0	0	1 (0.23)	1 (0.23)
	S	*Kartinikus colonus*	0	2 (0.45)	15 (3.38)	20 (4.50)	0	16 (3.60)	53 (11.94)
		Telodeinopus cananiculatus	0	0	0	7 (1.58)	8 (1.80)	0	15 (3.38)
		Treptogonostreptus intricatus	0	0	0	5 (1.13)	0	0	5 (1.13)
		Urotropis carinatus	0	0	0	0	0	12 (2.70)	12 (2.70)
Spirobolida	Pachybolidae	*Pelmatojulus excisus*	0	0	0	4 (0.90)	0	0	4 (0.90)
		Pelmatojulus tectus	0	16 (3.60)	0	6 (1.35)	0	8 (1.80)	30 (6.76)
Stemmiulida	Stemmiulidae	*Stemmiullus nigricolis*	0	0	0	0	0	9 (2.03)	9 (2.03)
	Total		10 (2.25)	164 (36.94)	22 (4.95)	158 (35.59)	11 (2.48)	79 (17.79)	444 (100)

Millipede species diversity among type of vegetation

In general, the Simpson Diversity Index is near 0 (λ= 0.12), suggesting a highly diverse millipede community. Furthermore, swamp forest and primary forest showed the highest values of Shannon-Weaver Index (H'= 2.46 and H'= 2.27 respectively), whilst the farmland showed the lowest (H'= 0.50). Moreover, farmland, secondary forest, palm oil plantation and fallow areas showed the highest values of Berger-Parker index, suggesting a very low species diversity in those communities (Table 2). Swamp forest and primary forests showed the lowest values of Berger-Parker index, suggesting a very high species diversity (Table 2). Pairwise comparison revealed highly significant differences among types of vegetation except among farmland and palm oil plantation, farmland and secondary forest, fallow areas and palm oil plantation and palm oil plantation and primary forest (Table 2).

Table 2 : Diversity indices among different vegetation types.

Type of vegetations	N	S	Simpson	Shannon-Weaver			Evenness	Margalef	Berger-Parker dominance
				H'	H'max	H'min			
Farmland	10	2	0.68	0.50	2.16	1.09	0.82	0.43	0.80
Fallow	164	7	0.47	1.09	2.65	2.34	0.43	1.18	0.66
Palm oil plantation	22	4	0.50	0.97	2.48	1.67	0.66	0.97	0.68
Swamp forest	158	17	0.12	2.46	2.67	2.32	0.69	3.16	0.26
Secondary forest	11	4	0.55	0.89	2.15	1.24	0.61	1.25	0.73
Primary forest	79	14	0.13	2.27	2.64	2.17	0.69	2.98	0.20
Total	**444**	**25**	**0.12**	**2.58**	**2.65**	**2.45**	**0.53**	**3.94**	**0.27**

Pairwise comparison of Shannon-Weaver index amongst vegetation types

Farmland vs fallow area: t = -3.011; ddl = 14.247; p < 0,01*
Farmland vs palm oil plantation: t = -1.668; ddl = 27.88; p >0,05
Farmland vs swamp forest: t = -9.6878; ddl = 12.955; p < 0,0001***
Farmland vs secondary forest: t = -0.841; ddl = 18.278; p >0,05
Farmland vs primary forest: t = -8.259; ddl = 15.035; p < 0,0001***
Fallow area vs palm oil plantation: t = 0.820; ddl = 30.891; p >0,05
Fallow area vs swamp forest: t = -12.198; ddl = 314.99; p < 0,0001***
Fallow area vs secondary forest: t = 1.037; ddl = 12.757; p < 0,0001***
Fallow area vs primary forest: t = -9.0015; ddl = 200.22; p < 0,0001***
Palm oil plantation vs secondary forest: t = -7.3351; ddl = 28.212; p < 0,0001***
Palm oil plantation vs primary forest: t = -0.4241; ddl = 20.187; p >0,05
Swamp forest vs secondary forest: t = 5.3634; ddl = 12.24; p < 0,0001***
Swamp forest vs primary forest: t = 1.9381; ddl = 171.79; p < 0,01*
Secondary forest vs primary forest: t = -4.5646; ddl = 13.081; p < 0,0001***

Similarity between millipede communities

Based on the Bray-Curtis index, the cluster analysis revealed the existence of two separate groups : the first group is formed by the secondary forest and farmland, wheras the second group is formed by fallow areas, swamp forest, primary forest and palm oil plantation (Figure 1). In the second group, primary forest and palm oil plantation communities were more similar between each other than that communities were similar to that of fallow and swamp forest. Between all clusters, the Bray-Curtis distance is very short, suggesting a high similarity among types of vegetation.

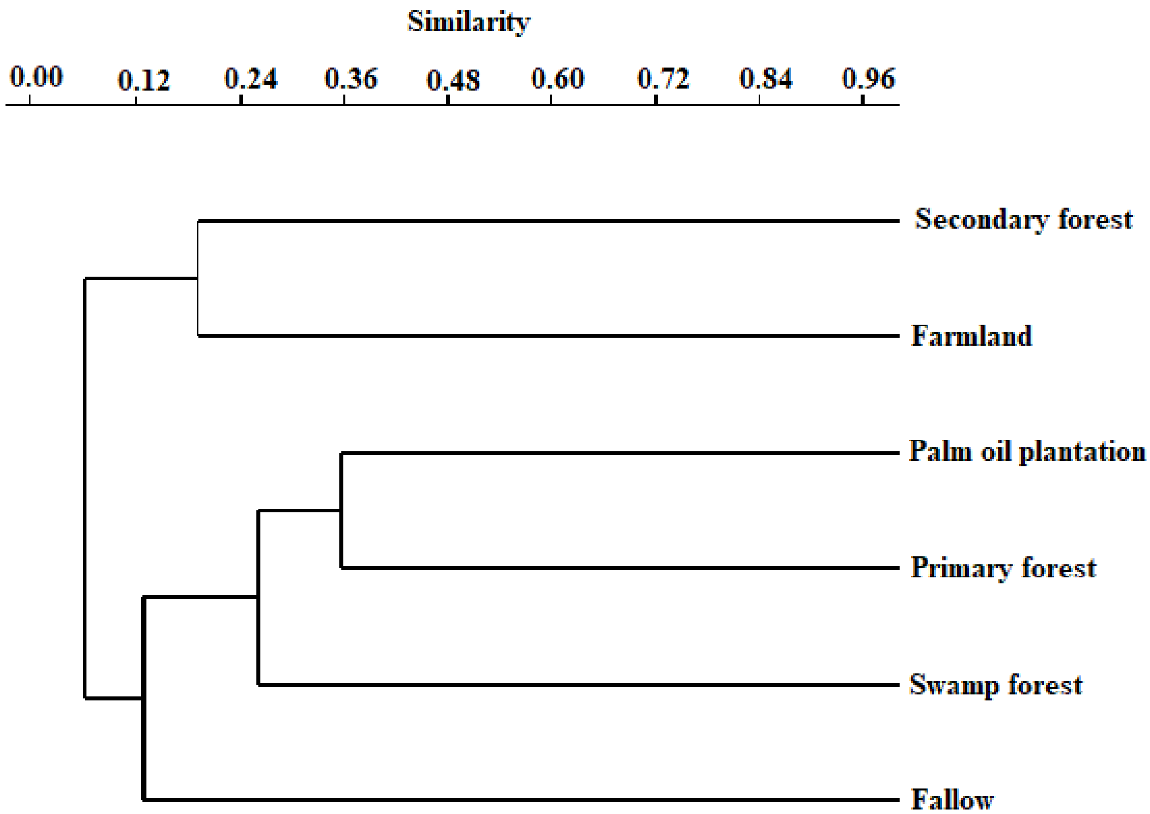

Figure 1. Cluster Analysis based on Bray-Curtis distance showing dissimilarity in milipede community among types of vegetation.

Distribution of milipede species among types of vegetation

No species occurred in all the type of vegetation. Nevertheless, *Coromus* sp., *Hemisphaeroparia mouanko*, *Kartinikus colonus*, *Trichochalepuncus* sp. and *Urodesmus cornutus* were widely distributed as they occurred in four habitat types (Table 3). Species like *Afolabina sanguinicornis*, *Coenobothrus bipartitus*, *Coenobothrus detruncatus*, *Coromus barumbi*, *Diaphorodesmoides* sp., *Diaphorodesmus dorcicornis*, *Kyphopyge granulosa*, *Paracordyloporus trisolabris*, *Pelmatojulus excisus*, *Spirostreptus pancratius*, *Stemmiullus nigricolis*, *Treptogonostreptus intricatus* and *Urotropis carinatus* were site specific as they were exclusively present in one habitat type (Table 3).

Table 3. Distribution of Millipede species among type of vegetations (+ = presence ; - = absence).

Species	Farmland	Fallow	Palm oil plantation	Swamp forest	Secondary forest	Primary forest
Afolabina sanguinicornis	-	-	-	+	-	-
Aporodesmus gabonicus	-	-	-	+	-	+
Coenobothrus bipartitus	-	-	-	-	-	+
Coenobothrus detruncatus	-	-	-	+	-	-
Coromus barumbi	-	-	-	+	-	-
Coromus sp.	+	+	-	+	+	+
Coromus vitatus	-	-	-	+	-	+
Diaphorodesmoides sp.	-	-	-	+	-	-
Diaphorodesmus dorcicornis	-	-	-	-	+	-
Hemisphaeroparia mouanko	-	+	+	+	-	+
Kartinikus colonus	-	+	+	+	-	+
Kyphopyge granulosa	-	-	-	+	-	-
Laciniogonus sp.	-	-	-	-	-	+
Paracordyloporus porati	-	+	-	+	-	-
Paracordyloporus trisolabris	-	-	-	-	-	+
Pelmatojulus excisus	-	-	-	+	-	-
Pelmatojulus tectus	-	+	-	+	-	+
Spirostreptus pancratius	-	-	-	-	-	+
Stemmiullus nigricolis	-	-	-	-	-	+
Systodesmus valdaui	-	-	-	+	-	+
Telodeinopus cananiculatus	-	-	-	+	+	-
Treptogonostreptus intricatus	-	-	-	+	-	-
Trichochalepuncus sp.	+	+	+	-	+	-
Urodesmus cornutus	-	+	+	+	-	+
Urotropis carinatus	-	-	-	-	-	+
Total number of species	**2**	**8**	**4**	**17**	**4**	**15**

Species abundance distribution in each habitat

Adjustment of millipede community to the commonly known theoretical species abundance distribution models showed that in general, millipede community distribution fitted the log normal model (m= 0.9088 ; v= 0.3459 ; P= 0.1058) (Fig.2A). In the fallow areas, the species distribution fitted the Fisher log series model (α= 1.485 ; x= 0.991 ; P= 0.123) (Fig.2B). The same trend was observed in the palm oil plantation (α = 1.429 ; x= 0.939 ; P= 0.2643) (Fig.2C). In the swamp forest, the species abundance distribution fitted the broken stick model (P= 0.9002) (Fig.2D). The same trend was observed in the secondary forest (P= 0.1367) (Fig.2E). In the primary forest, millipede community distribution fitted the Motomura model (m= 0.2123 ; P= 0.9883) (Fig.2F).

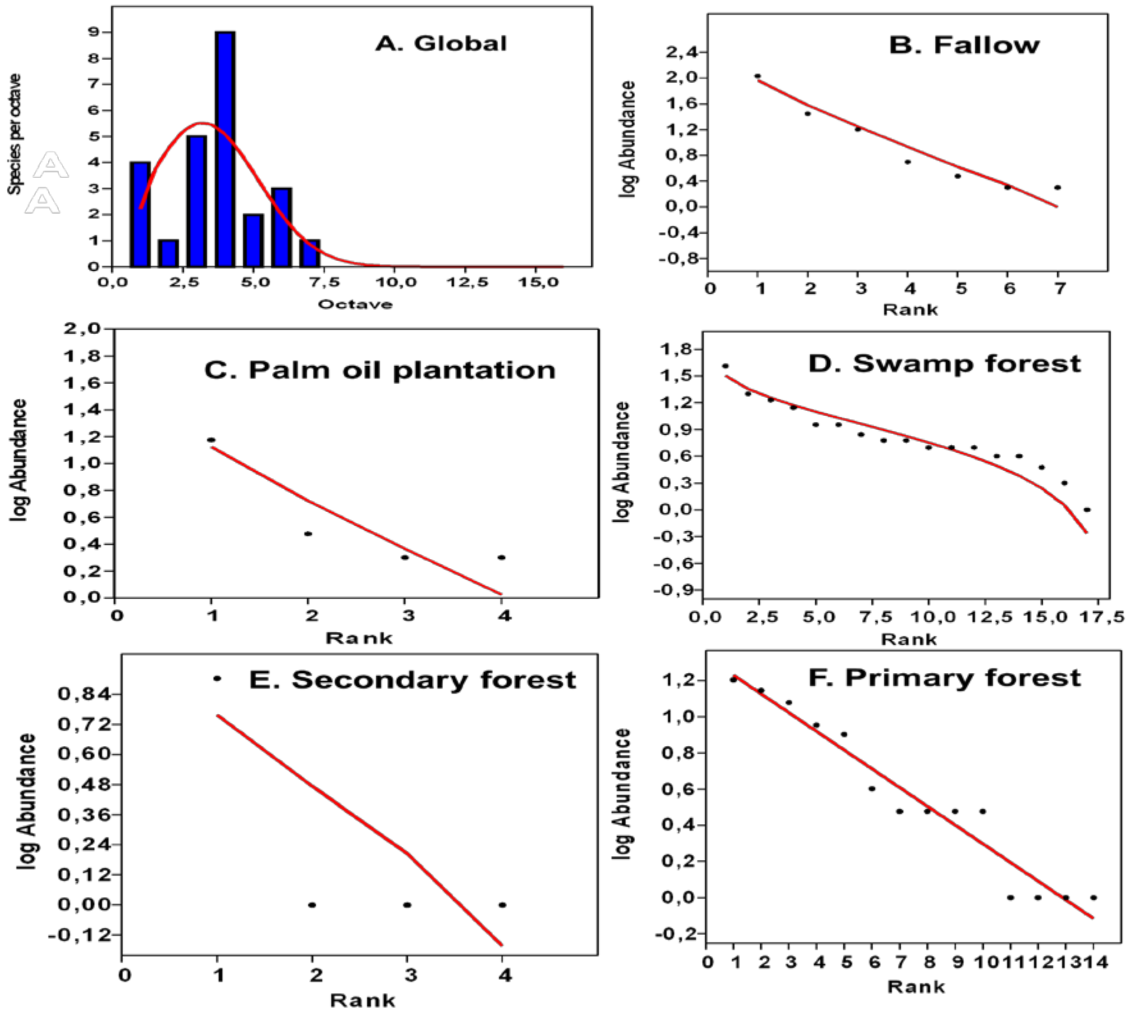

Figure 2. Millipede species abundance distribution among habitat types.

Antropogenetic activities and threats to millipede in and around Douala-Edea Wildlife Reserve

Various pressures on natural ecosystems by the local populations living in and arround the Douala-Edea Wildlife Reserve (actually transformed into a national park) were assessed. These pressures ranged from clear-cuts to the uncontrolled exploitation of forest species as *Lophira alata*, *Pycnanthus angolensis* and *Baillonella toxisperma*. A very intensive agricultural activity with destructive practices, such as slash and burn, was 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 plants 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. It is also apparent from this study that population of Mouanko (Douala-Edéa Wildlife Reserve) is 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 millipde 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-Edéa Wildlife Reserve of Cameroon are bushfires, agricultural practices, clear cutting for the production of coal, use of chemicals in cocoa and palm oil plantations, but also artisanal timber exploitation and over-use of chemicals.

Picture taken during the field activities

Pelmatojulus excisus

Telodeinopus cananiculatus

Coromus sp.

Coromus vitatus

Aporodesmus gabonicus

Systodesmus valdaui

National Park of Douala-Edea office

Field session in the National Park of Douala-Edea

Reapariant people activities in and around the Douala-Edea National Park.