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Distribution of *Lymnaea natalensis* deposits, intermediate-host of *Fasciola gigantica*, in the grazing lands of Far North region Cameroon

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Abstract
Fasciolosis is cosmopolitan disease of ruminants especially of the wetlands where intermediate hosts live. In Far-North Region of Cameroon, distribution of *L. natalensis* deposits is very little known. Manual malacological research carried out from February to June 2014 in105 water points of pastures reveal the presence of 30 *L. natalensis* deposits corresponding to 26.67% of sites studied. Deposits are only located in the Floodplains and in two water points of Mandara Mountains. A total of 15 Molluscs species are listed in all sites. *Biom. pfeifferi* and *Be. unicolor* are more significantly abundant (F = 1.62, ndl = 70, P = 0.094). In the deposits, 14 species have been identified with a very significant predominance of *L. natalensis* and *Biom. pfeifferi* (F = 10.39, n = 30, *P*<0.000) and Trematode hosts (F = 22.16, ndl = 1, P = 0.00000). Habitat influenced very significantly (F = 1.62, ndl = 25, P = 0.001) on the abundance of *L. natalensis* and justify the epidemiological importance of fasciolosis.

Keywords: Fasciolosis, *L. natalensis*, deposits, distribution, Far North region, Cameroon

1. Introduction
Lymnaea natalensis (Krauss, 1848) is a gastropod mollusk known as intermediate host of *Fasciola gigantica*, a parasite responsible for the fasciolosis of domestic and wild ruminants in Africa (Akogun and Okin, 1993; Allan *et al*., 2017) [4, 1]. Fasciolosis affects cattle by causing a general poor state, pronounced weight loss, diarrhea, dehydration with sunken eyeballs and liver lesions characterized by parenchymal hepatitis which then turns into cholangitis and cirrhosis (Tadelle and Worku, 2007; Robinson and Dalton, 2009) [53, 45]. Its economic importance is very high considering the significant losses of milk, meat, and seizures of parasitic livers in slaughterhouses (Tadelle and Worku, 2007) [53]. Usually known as animal parasitosis, fasciolosis is now considered as emerging zoonosis of humans (Robinson and Dalton, 2009) [45]. Pior 1992, infestation has increased from less than 3,000 people but today more it is than 17 million, with 91.1 million people living in high-risk areas (Keizer and Utzinger, 2005) [24]. The human infestations are reported from environments where animal fasciolosis is endemic and transmission occurs through water sources (deposits) common to humans and aquatic animals and plants (Robinson and Dalton, 2009) [45].
In Cameroon and the Far-North region in particular, there are large wetlands suitable for dry season farming (Scholte *et al*., 1995) [48]. However, these areas would overflow water points, markers of parasites and their intermediate host causing serious damage or death to animals and humans. Unfortunately, no information on their location, host density, or epidemiological involvement and human health importance is available.
The main purpose of this study is to determine the distribution of *L. natalensis* deposits on pasture lands in the Far-North Region of Cameroon. It is particularly about:
1. Determine the location and mapping of *L. natalensis* deposits;
2. Identify and characterize habitats preferably;
3. To determine the density, abundance and frequency of *Lymnaea natalensis* and its relationship with other species of Limners.

2. Materials and Methods
2.1 Milieu of studies
The Far North Region, lying between 10 ° and 13 ° north latitude and 14 ° and 16 ° longitude, has a Surface area of 34 262 km^2 (Leinou *et al*., 2003). This landscape is made of hilly reliefs

in places gives rise to four geo-ecological zones: Mount Mandara area, Plains of Diamaré zone, Plains of Logone area and the delta of Lake Chad area (Nouvelot, 1973; Ngounou Ngatcha *et al.*, 2007) [39, 38]. The climate is of the Sudano-Sahelian type characterized by a dry season which lasts 7 to 8 months, and a rainy season of 4 to 5 months (Leinou *et al*., 2003) [32]. Rainfall, which is generally lower than that of the other regions of the country, varies according to geographical area (Beauvilin 1995) [8] it is more important in the Mandara Mountains (850-1100 mm) and decreases considerably as one move towards the delta of Lake Chad (500-600 mm). The vegetation is made up of Sahelian species such as *Calotropis procera*, the Boron palm *Palassus flabellifer*, and the palm doum *Hyphaene thebaica*, *Acacia*, *Balanites*, *Ziziphus*, *Tamarindus*, *Acacia albida* (Zieba and Ganota, 2011).

2.2 Location of the deposit
During the period from February to June 2014, a survey of water points was carried out in the pastoral zones in order to detect the presence *L. natalensis* and to locate their lodgings. Every site visited once has been chosen because of pastoral importance and accessibility in order to include the different types of watercourses that cover a large possible area near the breeding. All water points have been located using GPS (Global Positioning System) GRAMIN Geko 301 to map the deposits of the region. Mapping of water points and *L. natalensis* deposit have been made using Arc Gis 10.2 system.

2.3 Search and harvest of limners
Malacological search is based on the standard harvest time-unit method described by Oliviera and Scheiderman (1956) [52]. The limners are researched and harvested according to the manual harvesting technique. This technique consists to direct collection by hand or by a net equipped with a 1.5m long handle by means if the level of the water and the quantity of the vegetation are important (Oliviera and Scheiderman, 1956) [42]. Sample was grouped according to their morphology and counted and backhand in the water. But a small amount of each sample is kept in vials containing 90 ° alcohol and taken to the laboratory for identification using the keys of Brown (1994) [9] and Day *et al*. (2003) [11]. The density of every species is determined according to the modified method of Sarr *et al* (2011) [46], by the number of limners harvested by the same person during 1 hour in each site. The presence of single *L. natalensis* living or dead is sufficient to characterize the site as a deposit of *L. natalensis*. Other species of molluscs present in the water point are also harvested and counted for characterization of habitat and environmental biodiversity assessment.

2.4 Statistical analyzes
All collected data were calculated on the basis of averages and percentages. Their interpretation was done through X2, Schwartz or Z tests, ANOVA, Duncan's test and Simpson and Shannon index. The X2 makes it possible to compare the percentages, the test of Z the comparison two to two of the percentages. The ANOVA compares the averages and the Duncan test for averaging was done using the XLSTAT evaluation software. The Simpson and Shannon index make it possible to evaluate the specific diversity of the environments studied.

The frequency of mollusks in is the ratio of the number of positive sites to a species of mollusk and the total number of sites surveyed times100.

Abundance is the ratio of Mollusk number of a species harvested and number of Mollusk total times 100.

3. Results
3.1 Sites studied
Throughout the period of this study, 105 sites were visited in the pastures of the geographical areas of the Region. These sites are aquatic habitats such as lakes, ponds, rivers, rivers, canals and bridges. They are located between 230 and 840 m altitude with a high concentration between 301-340 m altitudes (98.38%). Ponds are more common while lakes, rivers and canals are concentrated between 270-340 m above sea level. In these rangelands, half of the water points (50.48%) are permanent while the semi-permanent and temporary water points represent 22.86% and 26.67% respectively (Table 1). Permanent water points are statistically more abundant than semi-permanent (Z = 2.52, $P<0.05$) and temporary (Z = 3.37, $P<0.05$) water points.

Table 1: Distribution sites according to the duration of the water

Water Points	Permanent	Semi-permanent	Temporary
Number	53	24	28
Abundance (%)	50,48b	22,86a	26,67a

Values followed by the same letters do not show significant differences at the 5% level

3.2 Distribution of Lodgings of *L. natalensis*
3.2.1 Proportion of water points containing *L. natalensis*
For all the sites visited, *L. natalensis* was identified in 30 sites (Table 2). These deposits represent 26.67% of the sites studied. They are significantly more abundant in lakes (75%), streams (57%) and pools (44.83%) and less important in drains (11.54%), canals (12.5%) and rivers. bridges (20%) (Z = 3.3, $P<0.05$).

Table 2: Proportion of *L. natalensis* Settlement

Settlement	Sites Number	Shelter Number	Rate (%)
Lake	04	03	75a
Stream	07	04	57a
River	29	13	44,83a
Pool	52	06	11,54b
Drain	08	01	12,5b
Bridge	05	01	20b
Total	105	28	26,67

Values followed by the same letters do not show significant differences at the 5% level

3.2.2 Mapping of *L. natalensis* deposits
Surveys of GPS coordinates locate the majority settlements in the Flood Plains in yayrés along the Logone River (Figure 1). They are nonexistent in the Plains of Diamaré despite the presence of multiple semi-permanent and temporary water points. On the other hand, two deposits were identified at altitude, at the level of the Douvar reservoir and the small dam of Mokolo in the Mandara Mountains.

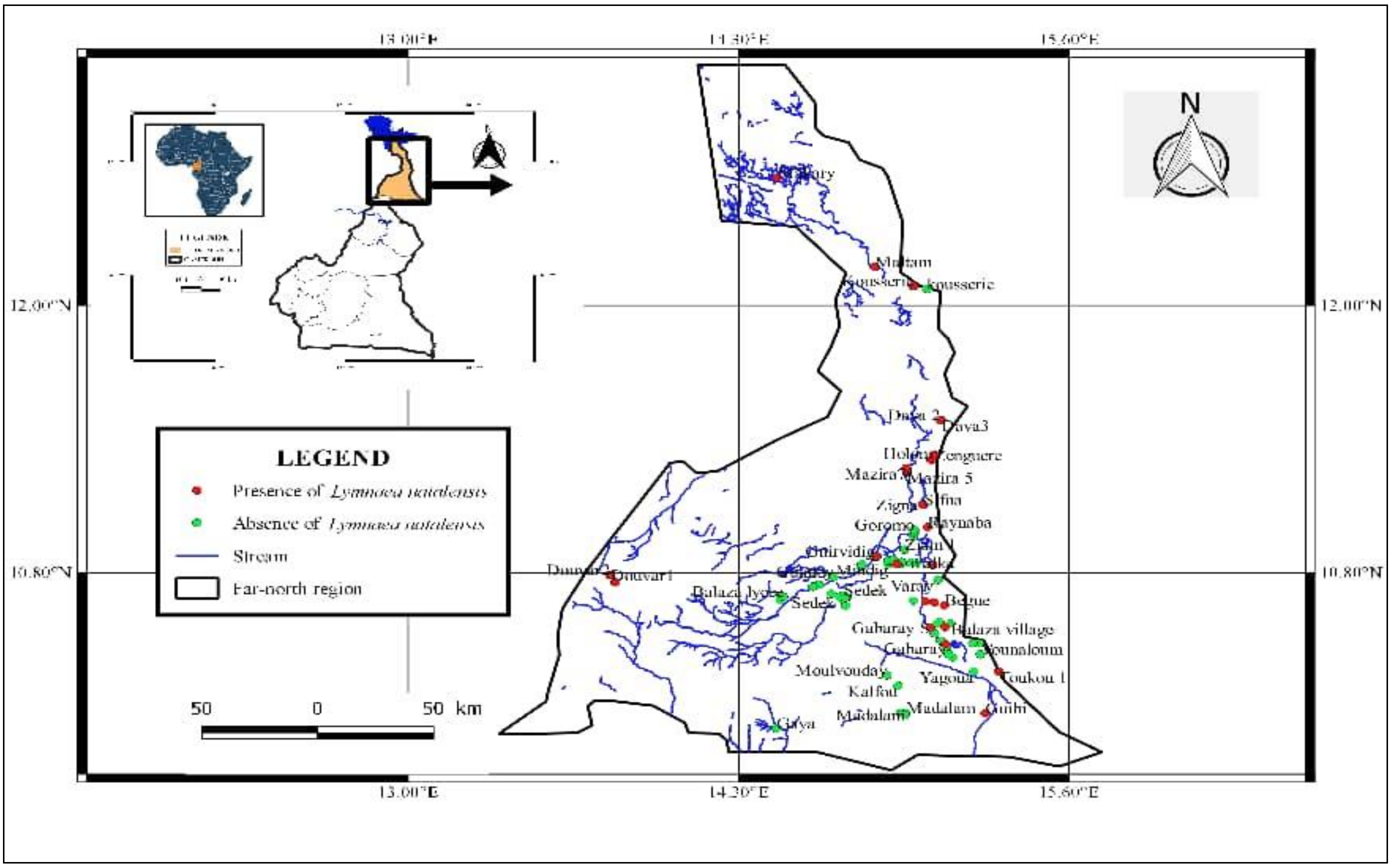

Fig 1: distribution of *Lymnaea natalensis* deposits in the Far North Region

3.3. Inventory of mollusks
3.3.1 Diversity of species
The inventory of harvested mollusks has identified 15 species of which 9 belong to Pulmonata orderly (Table 3). Among the Pulmonata, Planorbidae are represented with 7 species, 5 of which are sub-families of Bulininae (*Bulinus globosus*, *B. africanus*, *B. tropicus*, *B. truncatus*, *B. natalensis* and *B. forskalii*) and 2 of the sub-family Planorbinae (*Biomphalaria pfeifferie*, *Gyraulus costulatus*). Ampulariidae is second with 3 species (*Pila africana*, *Pila ampullacea*, *Pila wernei*). Viparidae, Lymnaeidae, Bithyniidae and Thiaridae are each represented by one specie (*Belamya unicolor*, *Lymnaea natalensis*, *Bithynia zeta* and *Melanoides tuberculata* respectively).

Table 3: Taxonomy of Harvested Mollusks Species

Class	Order	Family	S/Family	Genus	Species
Gastéropodes	Pulmonata Littorinimorpha	Lymnaeidae		Lymnaea	*Lymnaea natalensis*
		Planobidae	Bulininae	Bulinus	*Bulinus globulus*
				Bulinus	*Bulinus tropicus*
				Bulinus	*Bulinus africanus*
				Bulinus	*Bulinus forscalii*
				Bulinus	*Bulinus truncates*
				Bulinus	*Bulinus natalensis*
			Planorbinae	Gyraurus	*Gyraurus costulatus*
				Biomphalaria	*B Biomphalaria pfeifferi*
		Viviparidae		Belamya	*Belamya unicolor*
		Bithyniidae		Bithynia	*Bithynia zeta*
					Pila Africana
	Architaenioglossa	Ampulariidae		Pila	*Pila ampullaceal*
					Pila wernei
	Prosobranchia	Thiaridae	Melaniinae	Melanoïdes	*Melanoïdes tuberculate*

2.3.2 Frequencies of the limners
Depending on the frequency of the species in the sites (Table 4), the most frequent or ubiquitous species such as *B. globosus* and *P. africana*, *P. ampullacea*, *P. wernei* and *B. tropicus* are distinguished; frequent or accessory species like *L. natalensis*, *Biom. pfeifferi*, *Be. unicolor*, *B. truncatus* and *B. natalensis*; less frequent or accidental species such as *B. africanus*, *B. forskalii* and *Bi. zeta*; rare species like *M. tuberculata* and *G costilatus*. The species are also distributed differently according to the habitats (Table 5). *B. globosus*, *Pila africanus*, *P. ampullacea*, *P. wernei*, *Biom. pfeifferi*, *B. truncatus*, *Biom. pfeifferi*, *L. natalensis* and *B. tropicus* are cosmopolitan (more widespread) whereas *Be. unicolor*, *B. forskalii*, *B africanus* and *M. tuberculata* are moderately widespread. *Bithynia zeta* and *G. costilatus* are much localized.

Table 4: Mollusk Frequencies by Site and Habitat Type

Species	Number of Positives Site/105	Frequency (%)	Number of Positives Settlement /6	Frequency (%)
L. natalensis	30	28,57	04	66,67
B. globosus	75	71,43	06	100
B. tropicus	57	54,29	04	66,67
B. africanus	11	10,48	02	33,33
B. forscalii	10	09,52	03	50
B. truncatus	18	17,14	05	83,33
B. natalensis	16	15,24	02	33,33
Me. tuberculata	04	03,81	01	16,67
G. costulatus	02	01,9	01	33,33
Biom. pfeifferi	26	24,72	05	83,33
Be. unicolor	23	21,9	03	50
Pila africanus	82	78,09	06	100
Pila ampullacea	76	72,38	05	83,33
Pila wernei	79	75,24	06	100
Bithynia zeta	08	07,62	03	16,67

2.3.3 Abundance of mollusks in the sites

For all sites, 12,552 limners were counted (Tables 5). *Biom. pfeifferie* and *Be unicolor* are the most abundant species. They are supported by *L. natalensis*, *P. ampullacea* and *Bith. zeta* while *G. costulatus, B. forkali*i and *B. africanus* are less abundant. But these results show no significant difference (F = 1.62, ndl = 70, P = 0.094). However, the intermediate hosts of trematodes (*B. globulus, L. natalensis, B. africanus, B. tropicus, B. truncatus and B. forskalii, Biom. pfeifferie*,) constitute the group significantly more abundant (47.11%) (Z = 16.35, nd1 = 1, *P*<0.05). In this group *Biom. pfeifferie, L. natalensis and B. globosus* are the most numerous, whereas *B. forskalii* and *B. africanus* are rare. *L. natalensis* represents 22.9% of the trematode hosts. It colonizes all types of habitat and is most abundant in lakes, rivers and in ponds. It was harvested on the banks, plant roots, stems and plant debris. The habitat also has a significant influence (F = 1.62, ndl = 25, P = 0.001) on the abundance of limners because they are found in large quantities in rivers and ponds. They are less abundant in lakes and canals and scarce in the river and bridges (Table 5).

Species richness ranges from 1.61 in canals and bridges to 2.4 in lakes (Table 5). Lakes and rivers are richer in species. In addition, the computation of diversity indices shows that Simpson's index of these habitats are very low, ranging from 0.11 in lakes and rivers to 0.25 in rivers (Table 5). These habitats are likely to contain a very large number of different species. However, the most diverse habitats in Mollusk fauna are lakes and rivers.

Table 5: Abundance of Limner in different habitat types

	Mollusk Habitat							
Shell Species	**Lake**	**stream**	**River**	**Pool**	**drain**	**bridge**	**Total**	**Mean**
L. natalensis	469	38	522	319	00	06	1354	225,67
Biom. pfeifferi	346	322	211	282	256	80	1497	249,5
B. africanus	48	00	53	111	00	00	212	35,33
B. tropicus	53	34	234	144	123	48	636	106
B.unicolor	279	117	527	00	397	203	1523	253,83
Bithynia zeta	213	00	578	00	173	00	964	160,67
B. globosus	258	105	246	393	151	124	1277	212,83
B. forskalii	56	00	41	00	36	00	133	22,167
Me. tuberculata	414	00	65	00	00	00	479	79,83
B. truncatus	67	26	167	179	67	00	506	84,33
G. costulatus	86	00	11	00	00	00	97	16,17
B. natalensis	174	00	67	58	00	00	299	49,83
Pila africanus	58	36	426	623	112	46	1301	216,83
Pila ampullacea	33	21	112	691	98	52	1007	167,83
Pila wernei	79	27	234	716	137	74	1267	211,17
Total	2633	726	3494	3516	1550	633	12552	2092
Mean	175,53bc	48,4a	232,93c	234,4c	103,33ab	42,2a		
Species Number	11	06	09	06	05	05	11	
Spécific Affluence (lnS)	2,40	1,79	2,20	1,79	1,61	1,61	2,40	
Shannon Index (H')	2,4	1,72	2,38	2,07	2,12	1,83	-2,45	
Simpson Index (D)	0,11	0,25	0,11	0,14	0,14	0,19	0,09	

Values followed by the same letters do not show significant differences at the 5% level

2.3.4 Abundance and frequency of mollusks in the deposits

In the roosts, 13/15 species were identified with *L. natalensis*. This is *Biom. pfeifferi, B. globosus, B. tropicus, G. costilatus, B. africanus, B. forskalii, Me. Tuberculata* and *Be. unicolor* (Figure 2). The amount of limenus harvested represents 55.43% of the harvests of all the sites. Comparing this rate with that of other non-breeding sites, we find that it is very significantly high (Z = 11.13, ndl = 1, P = 0.0000). The density of the lentils is higher at the Douvar High Dam in Mokolo and lower in the Lith pool at Doreissou (Table 6). Trematodes intermediate hosts are more numerous with a representatively rate of 62.54% (Z = 22.16, nd1 = 1, P = 0.0000). *L. natalensis* is more abundant in the Douvar reservoir, in the pools of Wankrum at Pouss and on the banks of the Serbewel at Kafder (Table 6). The average densities of *L. natalensis*, *Biom. pfeifferi*, *B. globosus* and *Be unicolor* are higher while that of *G. costilatus* is lower (Figure 2). These results show the existence of a very highly significant difference (F = 10.39, n = 30, *P*<0.000). The Duncan test classifies into four groups: the most abundant (*Biom pfeifferi*, *L. natalensis*), the moderately abundant species (*Be unicolor and B. globosus*), the least numerous species (*Me. tuberculata*, *B. africanus*, *B. forskalii and B. tropicus*) and rare species (*G. costilatus*).

Table 6: abundance of limner species in the deposits of *L. natalesis*.

				Shell species														
N°	**Locality**	**Deposit Name**	**Settlement**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	***Total***
1	Guirvidig	Lake Maga	Lake	26	17	00	06	09	56	31	00	00	04	12	12	19	00	192
2	Pouss	Wankrum	Pool	121	25	09	08	18	67	26	00	13	09	17	26	36	39	414
3	Pouss	Logone	Stream	09	03	00	02	04	24	00	00	00	00	00	29	57	00	128
4	Varay	Berge lac	Pool	56	21	07	00	13	19	26	00	05	11	9	15	06	00	188
5	Kaikai	Guerleo	River	34	44	06	16	00	35	56	11	00	15	21	07	09	00	254
6	Raynaba	Logone	Stream	17	18	00	11	15	67	00	00	00	00	00	00	00	00	128
7	Zigna	Arzigna	Pool	31	25	00	12	13	16	00	00	00	00	47	52	11	00	207
8	Kaziri	Dulu	Pool	27	51	00	37	25	53	00	00	00	06	07	09	11	00	226
9	Zenguere	Zengue	Pool	46	24	09	06	06	22	16	00	00	07	05	31	18	00	190
10	Holom	Logone	Stream	12	17	00	00	00	00	13	00	00	18	37	28	35	00	160
11	Dava1	Ardava	Pool	21	69	07	19	00	31	00	00	00	11	26	16	05	00	205
12	Dava 2	Aguni	Pool	59	32	00	13	05	18	00	00	00	08	00	27	00	00	162
13	Kousserie	Azarai	Pool	58	62	09	29	21	73	32	00	07	23	08	11	16	32	381
14	Doreissou	Lith	Pool	14	07	06	0	06	27	00	00	00	05	07	11	21	00	104
15	Gabaray S	Danay	River	24	12	00	37	00	27	19	00	00	26	17	34	05	00	201
16	Gabaray D	Galida	River	37	41	10	18	07	21	71	00	00	13	54	07	00	21	300
17	Begué	Memier	River	57	11	00	07	00	31	57	00	07	00	00	11	00	00	181
18	Kourbouk	Morday	River	07	09	00	06	04	13	27	00	03	00	11	00	07	09	96
19	Maga	Vrick	Lake	31	19	06	00	06	53	103	00	11	00	00	00	00	23	252
20	Mazira 1	Logmatiya 1	River	21	07	00	08	00	69	77	00	00	8	29	00	28	36	283
21	Mazira 2	Logmatiya 2	River	54	00	00	07	00	28	16	19	00	00	00	07	00	00	131
22	Mazira 3	Logmatiya 3	River	27	29	00	16	00	37	67	00	00	11	13	06	12	21	239
23	Mazira 4	Logmatiya 4	River	18	47	00	00	00	39	14	12	00	16	00	00	00	31	177
24	Mazira7	Logmatiya 7	River	44	26	00	13	00	72	52	00	00	00	00	00	00	00	207
25	Douvar1	Dam	lake	136	31	79	00	51	86	00	115	00	00	00	00	00	00	498
26	Douvar2	Dam	lake	79	56	36	00	19	77	00	189	00	00	00	00	00	00	456
27	Douvar 3	Dam	lake	73	27	19	00	21	121	00	76	13	07	00	00	00	00	357
28	Mokolo	Small dam	lake	27	09	12	00	04	17	00	34	00	00	00	00	00	00	103
29	Makari	Serbewel	River	121	35	11	31	05	64	79	00	31	56	29	14	16	29	521
30	Guibi	Lake guibi	lake	67	52	00	12	00	23	84	00	00	07	07	05	07	21	285
			Total	1354	826	226	314	252	1286	866	456	90	261	356	358	319	262	7226
			Mean	45,13	27,53	7,53	10,47	8,4	42,87	28,87	15,2	3	8,7	11,87	11,93	10,63	8,73	
			Abundance	18,82	11,48	3,14	4,36	3,5	17,87	12,03	6,34	1,25	3,63	4,95	4,97	4,43	3,64	
			Frequency (%)	100	96,67	46,67	66,67	63,33	96,67	63,33	23,33	26,67	60	63,33	66,67	53,33	33,33	

1 : *L. natalensis* ; 2 : *B. globosus* ; 3 : *B. africanus* ; 4 : *B. tropicus* ; 5 : *B. forskalii* ; 6 : *Biom. pfeifferi* ; 7 : *Be. unicolor* ; 8 : *Me. Tuberculata* ; 9 : *G. costilatus* ; 10 : *B. truncatus* ; 11 : *P. africana* ; 12 : *P. ampullacea* ; 13 : *P. wernei* ; 14: *Bi. zeta;*

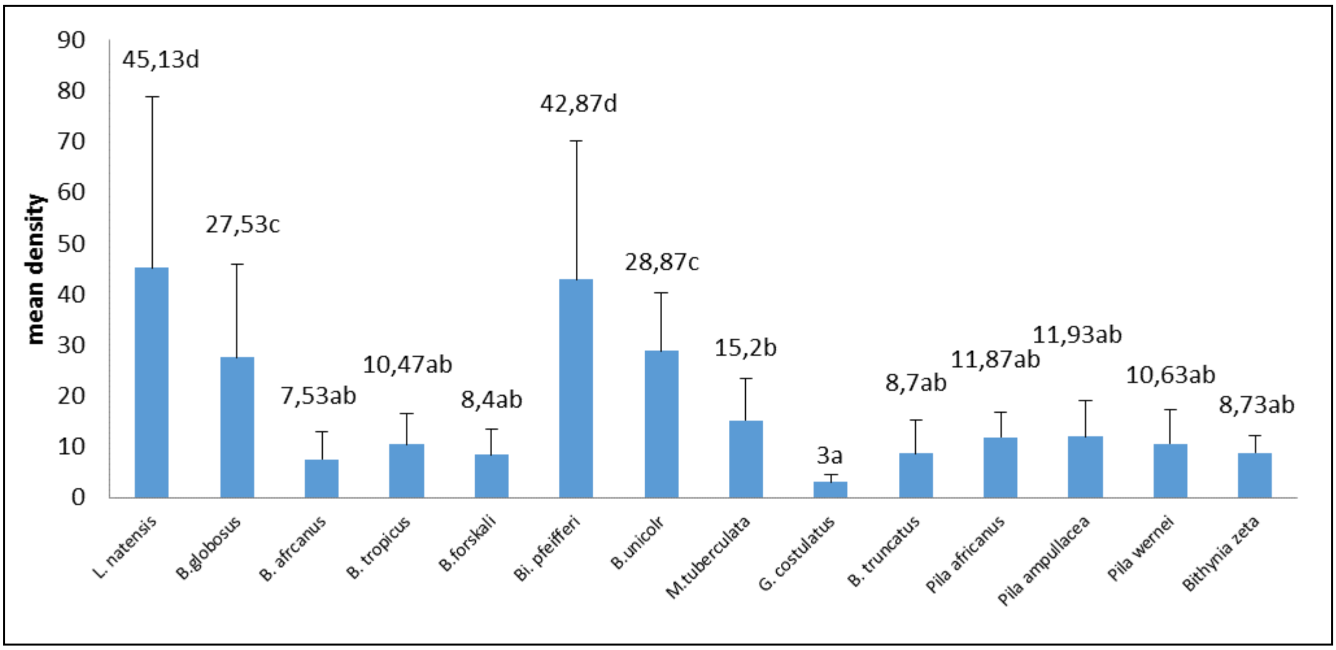

Fig 2: Distribution of mean densities of lentils in the deposits

According to the frequency of the species in the deposits (Table 5) we observe that *L. natalensis*, *B. globosus* and *Biom. pfeifferi* are very frequent or ubiquitous while *B. tropicus, P. ampullacea, B. unicolor, B. forskalii, Be. unicolor, P. africana* are frequent or accessory. *B. africanus* and *P. wernei* are less frequent or accidental then who *Bi. zeta, G costilatus, Me. tuberculata* are sedentary.

2.3.5.Relationships between species

The study of the relationships between the species of the deposits was conducted using Principal component analysis (Figure 3). The results show the existence of 11 types of links between species. *L. natalensis* established a highly significant links with *B. africanus* (r = 0.678; ndl= 13; p = 0.001), *B. forskalii* (r = 0.607; ndl=13; p = 0.000), *Biom. pfeifferi* (r = 0.55 ;ndl=13; *P* <0.002), *Me Tuberculata* (r = 0.471; ndl= 13;p = 0.009) and *G. costulatus* (r = 0.208; ndl=13 ;p = 0.011). Other link are also observed between *B. globosus* and *B. tropicus*; *B. africanus, B. forskalii, Biom. pfeifferi* and *Me. Tuberculata*; *B. tropicus, B. truncatus, P. africana* and *P. ampullacea*; *B. forskalii, Biom. pfeifferi, Be.unicolor* and *Me. Tuberculata; Biom. pfeifferi, Me. Tuberculata* and *G. costulatus; Be.unicolor, P. africana* and *Bi. zeta; G. costulatus, B. truncatus* and *P. africana; B. truncatus, P. africana, P. ampullacea* and *P. wernei*

2.3.6 Distribution of freshwater Molluscs in relation to *L. natalensis* deposits

The representation of the deposits according to the abundance and the number of the species shows that their distribution is not uniform in the pastures of the Far North Region of Cameroon (Figure 3). The deposits analyzed in the F1 x F2 plane are visible at 54.85% unlike the other axes. In the F1 x F2 plane, three clouds and one variable are observed. The dendrogram resulting from the Ascending Hierarchical Classification (AHC) shows that the first cloud is formed of the lodgings n° 1 to 6, 7 to 9, 11 to 14, and 21, 23, 24, 29 whereas the second cloud consists of Lodgings n° 5, 10, 16 to 20, 22 and 30 (Figure 4). Variable III is isolated with only one deposit (n° 15), while Cloud IV contains deposits n° 25 to 28. In cloud I, the deposits share 3 species (*L. natalensis*, *B. globosus* and *Biom. pfeifferi*) and mean densities of the population of *L. natalensis* and *Biom. pfeifferi* compared to those of other clouds are high. Their species richness is very high (5 to 13 species). The deposits of cloud II also have three species in common, but unlike those of cloud I, the third species is different (*L. natalensis*, *B. globosus*, *Be. unicolor*). The species richness is large (7-10 species) and among all these species, the population of *Be. unicolor* is the most important. The deposits of cloud IV have in common 6 species among which *L. natalensis*, *B. pfeiffeiri* and *Me. tuberculata* are more abundant. These deposits are also distinguished by the total absence of species no. 7, 11, 12, 13 and 14. Species # 15 of variable III is distinguished by the total absence of *B. africanus*, *B. forskalii*, *Me. Tuberculata*, *G. costulatus*, and *Bi. zeta*. Among the most abundant species present are *B. tropicus*, *B. truncatus* and *P.ampulacea*.

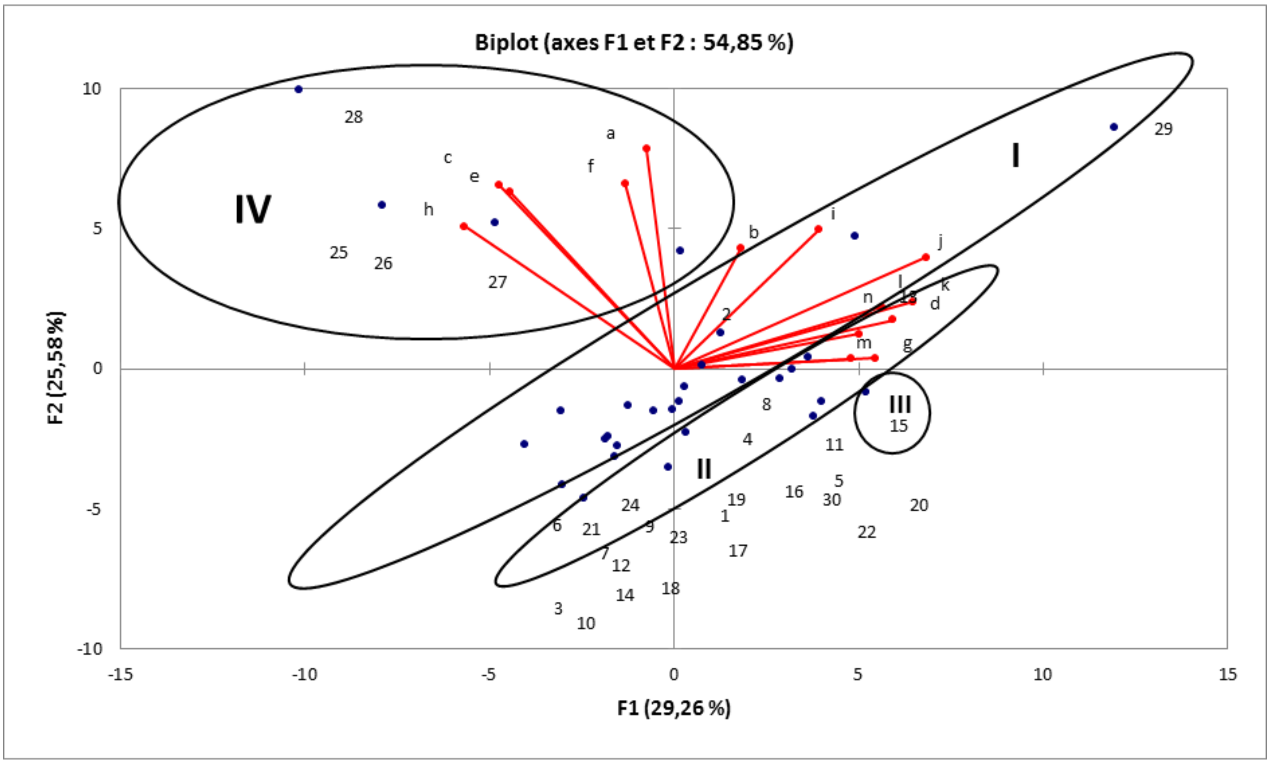

Fig 3: Relationships between Mollusk species and spatial disposition of deposits of *L. natalensis* Legend: a= *L. natalensis* ; b= *B. globosus* ; c= *B. afrianus* d=*B. tropicus*; e= *B. forskalii* ; f=*B. pfeifferi* ; g= *B. unicolor* ; h= *M. tuberculata* ; i= *G. costulatus;* j= *B. truncatus*; k= *Pila africanus*; l= *P. ampullaceal*; m= *P. wernei*; n= *Bith. zeta* ; 1=lake Maga ; 2= Wankrum stream ; 3= Logone Pouss ; 4= Varay strea; 5= Guerléo ; 6= Logone Raynaba ; 7= Arzigna ; 8= Dulu; 9= zengue stream ; 10= Logone Holom 11=Ardava ; 12= Aguni ; 13= Azarai ; 14= lith ; 15= Danay Mousouk; 16= Galida; 17= Memier; 18= Morday; 19= Mayo-Vreck; 20= Logmatiya1; 21= Logmatiya 2; 22= Logmatiya 3; 23= logmatiya; 24= Logmatiya 7; 25= Douvar 1; 26= Douvar 2; 27= Douvar 3;28= Mokolo small dam; 29= Serbewel; 30= Guibi lake

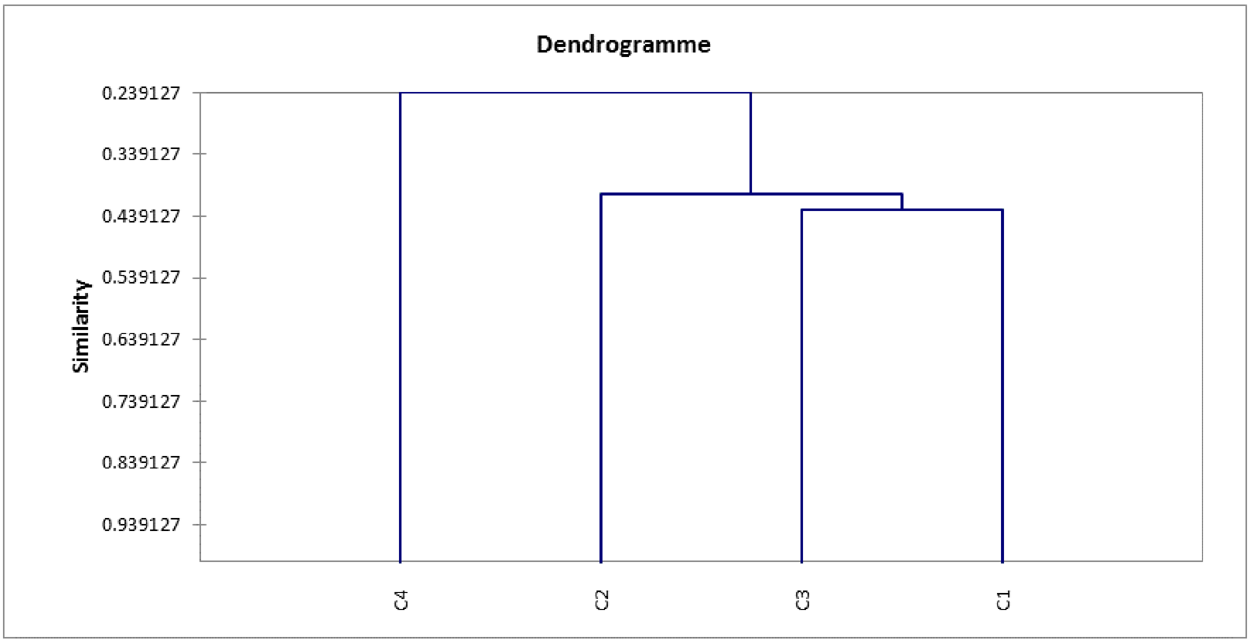

Fig 4: dendrogram from the ascending hierarchical classification (AHC) of *L. natalensis* deposits

3. Discussion

3.1 Permanence of water

The study reveals 50.48% of the permanent water points in the pastures in the dry season prove that water is a priority resource in the breeding practice. According to Zieba and Ganota (2011), L'Hote *et al*. (2002) [27] and Lebel *et al*. (2009) [29], in the Sahelian zone water is the scarce resource, especially in the dry season and the permanent object of agropastoral conflicts.

3.2 Distribution of *L. natalensis* deposits

The *L. natalensis* deposits represent 26.67% of the studied sites and are located in the flood plains. This low rate is deposits similar in with observation of Kochi *et al*. (2013) [26] in Ivory coast (23.12%), Komba *et al*. (2017) [25] in Gabon (25.47%) and dissimilar with result of Sarr *et al*. (2011) [46] in Senegal (56.14%), Ibikounlé *et al*. (2013) [19] and Ntonifor and Ajayi, (2007) [40] in Nigeria (47,5%, 57,24% respectively). According to Tadonkeng (1993) [54] and L'Hote *et al*. (2002) [27], very high temperatures in the dry season accelerate the evaporation of water and the total drying of water points. Absence of deposits in Diamaré plains is related with his sandy soils who favor the rapid infiltration of water points one month after the rainy season (L'hote *et al*., 2002) [27]. According to Vassiliades (1978) [57], Sarr *et al*. (2011) [46] and Kochi *et al*., (2013) [26], *L. natalensis* prefers shallow permanent water points because of his very low resistance capacity to extreme drought hence its presence in perennial water points.

The presence of two deposits of *L. natalensis* in the area of the Mandara Mountains demonstrates his large distribution. This result is similar with observation of Van Eden *et al*. (1965) [56], Hussein *et al.* (2011) [17] and Dillon (2000) [13], that *L. natalensis* can survive in mountainous and desert regions such as in southern Algeria (Tassili N'Ajjer and Ahaggar) in northern Niger (Air) and Chad (Tibesti). This comportment can be a strategy to escape to the extreme drought and to regulation of his population in the downstream plains. According to Leroux *et al*. (2013) [30] and Ngounou Ngatcha *et al*. (2007) [38] Mountain environment offers a moderate climate with a permanence of the waters. In the rainy season, important quantities of Molluscs are dumped with the waters of Mayo-Tsanaga (0.5 to 1 billion cubic meters) to repopulate the rivers in the Floodplains and the Lake Chad Delta (Nouvelot, 1973; Leroux *et al*., 2013) [39, 30].

Lakes, stream and rivers are the most important habitats because they are full of water permanently (Dillon, 2000) [13] and offer favorable conditions the development and survival of mollusks. This result confirm the observation of Kochi *et al*. (2013) [26] that *L. natalensis* is found of permanent water points because it does not have a lid to sink into the mud and to hibernate for longer.

3.3 Fauna and diversity of mollusks

The 15 species of mollusks recorded are cosmopolitan and well known in Central and Sub-Saharan Africa (Brown 1994; Ibikounlé *et al*., 2009; Ndassa and Mimpfoundi, 2005; Edward, 2011) [9, 37, 18, 15]. They all belong to the class of gastropods. This result is similar with the result of Ibikounlé *et al*. (2009) [18] in Benin and Olowusi-Peters (2017) [41] in Nigeria who find only 13 and 11 gastropods species respectively. But it differs with result of Garg *et al.* (2009) [16] in India who found 2 Class with a predominance of Gastropod. According to Dillon (2000) [13], Lévêque (2008) [31], Isabwe *et al.* (2012) [21], abundance of gastropods in freshwaters can be explained by abundance of Macrophytes. Planorbidae are predominant family of gastropods because of their preference for alkaline freshwater in the Sahelian region (Brown, 1994; Ndassa and Mimpfoundi 2005; Ibikounlé *et al*., 2014) [9, 37, 20]. Their importance is also related to their role as host-mediators of parasitic infections (Ntonifor and Ajayi, 2007; Kane *et al*., 2008, Joergensen *et al*., 2010; Nalugwa *et al*., 2010; Isabwe *et al*., 2012; Kotchi *et al*., 2013; Zaghloul *et al*., 2013) [40, 23, 22, 36, 21, 26, 61]. *B. globosus* is host to *Schistosoma haematobium* in several African countries (Ibikounlé *et al*., 2013) [19]; *B. forskalii* transmits *S. intercalatum* in Cameroon (Ndassa and Mimpfoundi, 2005) [37], Gabon (Koumba *et al*., 2017) [25], Chad (Wendelin *et al*., 2014) [59], Nigeria (Owojori *et al*., 2006; Ntonifor and Ajayi, 2007; Mofolusho and Benson, 2015) [43, 40, 34], Senegal (Lebel *et al*., 2009) [29]; *L. natalensis* is the intermediate host of *F. gigantica* (Lebel *et al*., 2009; Zaghloul *et al*., 2013) [29, 61].

3.4 Abundance of Mollusks
3.4.1 Abundance in the sites
The counts performed in all the sites show that *Biom. pfeifferie* and *Be. unicolor* are more numerous. They are supported by *L. natalensis*, *P. ampullacea* and *Bi. zeta*. Several authors have also reported similar observation that *Biom. pfeifferi* is more abundant in the fresh waters of Sahelian Africa (Dillon 2000, Ndassa and Mimpfoundi 2005, Ntonifor and Ajayi 2007, Sarr *et al*., 2011, Skelton and Swartz, 2011) [13, 37, 40, 46, 50] because *B. pfeifferi* is fond of low-flow stagnant water (Skelton and Swartz, 2011) [50]. However, this result is not in accordance with many authors who reveal predominance of other species such as *B. forskalii* in Benin (Ibikounlé *et al*., 2014) [20], *Pissidium mitchelli* in Gho-Manhasan streams in Egypt (Schamar *et al*., 2013) and *B. globosus* in Angola (Allan *et al*., 2017) [1]. These differences can be explained by the ability to withstand fluctuations in salinity, decomposition processes of dead plants, extreme temperatures and drying up of watercourses (Sarr *et al*., 2011) [46]. Anthropogenic factors can also be implicated, because in the Cameroon Logone Valley, Slootweg *et al*. (1992) collected in 1982 a large number of *B. forskalii* and a very small number of *B. truncatus* at SEMRY II of Maga drain. But 10 years later, the inventories show that *Biom. pfeifferi, B. truncatus and B. globosus* are more numerous whereas *B. forskalii* is only a minority. Diversity index obtained are low in lakes and rivers (H '= 0.11), ponds and canals (H' = 0.14), bridges (H '= 0.19) and rivers (H '= 0.25) is disimilar with the result of Dida *et al.* (2014) in the Tiger River (H '= 0.518) and similar with the result of Pulangui Lake (H' = 0.144). This could be as a result of the quality of the environment and the nature of the sediment. According to Desccheins (1956) [12], Bakulu *et al.* (1989) [6], Dundee and Paine (1999) [14], the quality of an aquatic ecosystem depends on environmental factors, which in turn can influence the structuring of aquatic communities. A similar result was obtained by Mustapha and Yakubu (2015) [35] in Oyun reservoir (Nigeria). Furthermore, Asibor (2015) [3], Edward an Ugwumba (2011) [15] and Shailendra *et al.*, (2013) [47] observed mollusca as the dominant macro-benthic invertebrates in Asejire and Agbe Reservoir in Nigeria and in Kunda River in India respectively.

3.4.2 Abundance in the deposit
Importance of species harvested in the deposits is related to the permanence of the water and the particular ecological conditions (Poda *et al*., 1996; WHO, 2010) [44, 60]. In these deposits, limners are very abundant because of water that facilitates larval development and the rapid proliferation (Baluku, 1987; Dillon, 2000; Garg *et al*., 2009; WHO, 2010; Olawusi-Peters, 2017) [5, 13, 16, 60, 41]. According to Lévêque *et al*. (2011), abundance of gastropods is fostered by freshwater and aquatic vegetation. Intermediate hosts of trematodes are more abundant because of their epidemiological importance in the transmission of schistosomes and fascioliasis (Wendelin *et al*., 2014) [59]. According to the WHO (2010) [60], bilharziasis is the second tropical disease with 600 million people exposed worldwide, more than 200 million cases of infestations and nearly 280 000 deaths each year among which 97% in South Africa of the Sahara. Dominance of *L. natalensis* in their deposit is reported by Wendelin *et al*. (2014) [59] in Chad and Ugwumba (2012) [55] in Nigeria. Nevertheless, in the same country in Nigeria, Edokpayi *et al.* (2000) and Olawusi-Peters (2017) [41] show dissimilar result that *L. natalensis* is not dominant species. Abundance of *Biom. pfeifferi, B. globosus, B. africanus, B. forskalii and B. tropicus* would reflect the importance of anthropogenic activities around these deposits and the risk of transmission of human fasciolosis (Lietar, 1956; Garg *et al*., 2009; WHO, 2010) [33, 16, 60]. Andem (2012) [2] further observed high abundance of *Me. tubaculata, B. globosus* and *L. natalensis* in Ona river in Nigeria. In addition, high number of *B. pfeifferi, B. globosus, L. natalensis* and *Me. tuberculate were* collected by Mofolusho and Benson (2015) [34] from Orori river, Bareke river, Osun river, Eleyele and Eko-Endo lakes, during their research work in south-western Nigeria.

3.4.3 Relationship between species
L. natalensis lives in association with *Biom. pfeifferi, B. africanus, B. forskalii, Me. Tuberculata and G. costulatus.* The link with *Biom. pfeifferi* has already been reported by several authors (Batumiké *et al*., 2014; Mofolusho and Benson, 2015; Mustapha and Yakubu, 2015) [7, 35, 34]. These results are similar with observations of Chantier *et al.* (1992) [10] and Andem *et al.* (2012) [2]. According to Batumiké *et al.* (2014) [7], they species colonize the same biotope like stagnant or slow-moving water and are parasitized by furcocercariae (Xiphidiocercaria and Gymnocephalus). Links between *L. natalensis* and other species are very poorly known. It would be wise to conduct further in-depth ecological studies in order to draw a comprehensive conclusion. The bonds between Schistosome hosts such as *B. globosus / B. tropicus, B. africanus / B. forskalii / Biom. pfeifferi, B. tropicus / B. truncatu*s *complexes* have also been observed. In Senegal, links between *B. globosus* and *B. truncatus* have been repported (Lebel *et al*., 2009; Sarr *et al*., 2011) [29, 46]. According to Owojori *et al*. (2006) [43], Mustapha and Yakubu (2015) [35], under similar geographical conditions, members of the *B. forskalii* group (*B. camerunensis* and *B. senegalensis*) can live together. In Nigeria, Ntonifor and Ajayi (2007) [40] observe *B. senegalensis* and *B. truncatus* complexes despite their very low numbers. *B. africanus* /*B. globosus* complex is frequently found at the continental scale (Shailendra *et al*., 2013; Batumiké *et al*., 2014) [47, 7], often replacing *B. truncatus* in streams and pools of forest (Ndassa and Mimpfoundi 2005) [37]. Their connection would be in relation to their preference for the same type of habitat. Ndassa and Mimpfoundi (2005) [37] show that *B. globosus* can live in both running water and stagnant water, but has a preference for shaded, putrid and poorly oxygenated water and in withstand many months of desiccation. However, *Biom. pfeifferi* colonizes several types of water collections in savannahs and forests. She is fond of collections of clear water on sand and gravel bottom and stagnant water or with a very light current, with sometimes abundant aquatic vegetation (Lietar, 1956; Nalugwa *et al*., 2010; Subba, 2003) [33, 36, 52]. According to Batumiké *et al*. (2014) [7], *B. forskalii* prefer calm, muddy, shallow waters containing dead leaves.

3.4.4 Distribution of freshwater Molluscs in relation to *L. natalensis* deposits
The clouds observed in the dendrogram correspond to deposits that differ from one another according to the abundance and diversity of the species. The first cloud, characterized by a great diversity of species and a predominance of *L. natalensis* and *B. pfeifferi* are located around human habitats and farms. These deposits would be a preferred area for transmission of fascioliasis and schistisomiasis and are classified according to the WHO

(2010) [60]. The second cloud, consisting of deposits with several species (in densities lower than that of other clouds) and strong dominance of *B. unicolor*, would be a secondary transmission zone of fasciolosis and Schistosomosis which forms the secondary breeding sites (WHO, 2010; Mustapha and Yakubu, 2015) [60, 35]. The deposits of cloud IV are distinguished by large populations of *L. natalensis*, *Biom. pfeifferi*, *Me. tuberculata* and the complete absence of most other species. In these deposits, pastures and dwellings are less important, but they are connected to a hydrographic network that converts water to the floodplains (Day, 2003; WHO, 2010) [11, 60]. This suggests that these are places of multiplication and proliferation of molluscs of medical importance. According to WHO (2010) [60], they are reservoir deposits. Variable III is absent from Variable III by the abundance of *B. tropicus*, *B. truncatus* and *P. ampulacea* and the total absence of *B. africanus*, *B. forskalii*, *Me. Tuberculata*, *G. costulatus*, *Bi. zeta*. But very little information is available to justify its demarcation. However, to better understand all these results it is necessary to deepen these results by studying physicochemical and ecological parameters.

4. Conclusion

The present study allowed us to locate the *Lymnaea natalensis* only in the Mandara Mountains and in the flood plains. In the Flood Plains, they are located in the wetlands along the Logone River while in the Mandara Mountains they are located in the reservoirs of Douvar and Moufuele in Mokolo. Fauna of mollusks is much diversified and is marked by the abundance of *Biom. pfeifferi* and *Be. unicolor* in all the sites and *L. natalensis* in the lodgings. The most important habitats of the limners are rivers and ponds. The proximity of these deposits with pastures and near villages demonstrates their involvement in the epidemiology of animal and human fasciolosis. Therefore, it is advisable to study the dynamics and ecology of the *L. natalensis* population in these deposits, the emission dynamics of *F. gigantica* larvae, and the serum prevalence of fasciolosis in animals and humans who live around.

5. Reference

1. Allan F, Jose Carlos Sousa-Figueiredo, Aidan M Emery, Rossely Paulo, Clara Mirante, Alfredo Sebastião, *et al*. Mapping freshwater snails in north-western Angola: distribution, identity and molecular diversity of medically important taxa. Parasites & Vectors. 2017; 10:460
2. Andem AB, Okorafor KA, Udofia U, Okete JA, Ugwumba AAA. Composition, Distribution and Diversity of Benthic Macroinvertebrates of Ona River, South-west, Nigeria. European Journal of Zoological Research. 2012; 1:47-53.
3. Asibor GI. Seasonal Biodiversity Assessment of Benthic Macro-invertebrate of Asejire Reservoir, Southwest Nigeria. Journal of Sustainable Development. 2015; 8:2-10.
4. Akogun OB, Okin BN. “The Ecology of Fresh Water Snails in Agro-Industrial Estate in Yola, Nigeria.” The Nigerian Journal of Parasitology. 1993; 14:75-80.
5. Baluku Bajope. Contribution à l’étude des hôtes intermédiaires des bilharzioses. Ecologie des mollusques *Biomphalaria pfeifferi* dans deux cours d’eau du Zaïre Oriental. Thèse de Doctorat, ULB. 1987, 487.
6. Baluku B, Josens G, et Loreau M. Etude préliminaire de la densité et de la répartition des mollusques dans deux cours d’eau du Zaïre oriental. Rév., Zool., Afr. 1989; 103:291-302.
7. Batumike PC, Bagalwa MJJ, Ndegeyi KB, Baluku BJP, Et Bahizire KJL. Contribution à l’inventaire et écologie des espèces Mollusques dulcicoles des petits cours d’eaux de Lwiro et ses environs, Est de la RD Congo. International Journal of Innovation and Applied Studies. 2014; 7(1):298-308.
8. Beauvilain A. Tableau de la pluviométrie dans les bassins du Tchad et de la Bénoué, de la création des stations à décembre 1994. N’Djamena, Centre national d’appui à la recherche (Cnar), Documents pour la recherche. 1995; 3:1-103.
9. Brown SD. Freshwater snails of Africa and their medical importance. Taylor and Francis, London, 1994, 1-487.
10. Chantier C, Bushu M, Kristensen TK, Nzeymana S, Lubingo M, Cabaret J. Inventaire des mollusques d’eau douce en Ituri (Haut Zaïre). Conséquences sanitaire pour l’homme et le bétail. Rea. Hydrobiol. Trop. 1992; 5(3):189-196.
11. Day JA, Harrison AD, De Moor IJ. Guides to the Freshwater Invertebrates of Southern Africa. Diptera. 2003; 2(9):1-210.
12. Deschiens R. Les actions mollucides dans le cadre de la prophylaxie des bilharzioses. Bull Soc Pathol Exot Filiales. 1956; 49(6):1264-1284.
13. Dillon RTJ. The Ecology of Freshwater Molluscs. Cambridge University Press, Cambridge, U.K, 2000, 1-523.
14. Dundee DS, Paine A. “Ecology of the Snail, *Melanoides tuberculata* (Muller), Intermediate Host of the Human Liver Fluke (*Opisthorchis sinensis*) in New Orleans, Louisiana.” Nautilus. 1999**;** 91(1):17-20.
15. Edward JB, Ugwumba AAA. Macroinvertebrates fauna of a tropical southern reservoir, Ekiti State, Nigeria. Continental Journal of Biological sciences. 2011; 4:30-40.
16. Garg RK, Rao RJ, Saksena DN. Correlation of molluscan diversity with physicochemical characteristics of water of Ramsagar reservoir. India. Int. J. Biodivers. Conserv. 2009; 6:202-207.
17. Hussein MA, Obuid-Allah AH, Mahmoud AA, Fangary HM. Population dynamics of freshwater snails (Mollusca: Gastropoda) at Qena Governorate, Upper Egypt. Egypt. Acad. J Biol. Sci. 2011; 3(1):11-22.
18. Ibikounlé M, Mouahid G, Sakiti NG. Freshwater snail diversity in Benin (West Africa) with a focus on human schistosomiasis. Acta Trop. 2009; 111(1):29-34.
19. Ibikounlé M, Mouahid G, Mintsa Nguema R. Snail intermediate host/*Schistosoma haematobium* relationships from three transmission sites in Benin (West Africa). Parasitol Res. 2013; 112(1):227-233.
20. Ibikounlé MA, Ogouyèmi-Hounto Y, Sissinto Savi de Tové A, Dansou D, Courtin D, Kindé-Gazard G, *et al*. Massougbodji. Épidémiologie de la schistosomose urinaire chez les enfants scolarisés de la commune de Péhunco dans le Nord Bénin : prospection malacologique. Bull. Soc. Pathol. Exot. 2014; 107:177-184
21. Isabwe A, Ruberanziza E, Mupfasoni D, Ruxin J, Clerinx J, White PT. Potential for transmission of schistosomiasis in Kayonza district. Rwanda Medical Journal. 2012; 69(2):14-19.

22. Jorgensen Aslak, Henry Madsen, Allen Nalugwa, Silvester Nyakaana, David Rollinson J. Russell Stothard and Thomas K. Kristensen. A molecular phylogenetic analysis of *Bulinus* (Gastropoda: Planorbidae) with conserved nuclear genes. Zoologica Scripta, 2010. doi:10.1111/j.1463-6409.2010.00458,
23. Kane RA, Russell Stothard J, Aidan M Emery, Rollinson D. Molecular characterization of freshwater snails in the genus *Bulinus*: a role for barcodes. Parasites & Vectors 2008; 1:15 DOI:10.1186/1756-3305-1-15;
24. Keiser J, Utzinger J. Emerging foodborne trematodiasis. Emerg. Infect Dis. 2005; 11:1-14.
25. Koumba M, Mipounga HK, Koumba AA, Zinga Koumba CR, Mboye BR, Jean Félicien Liwouwou JF, *et al*. Diversité familiale des macroinvertébrés et qualité des cours d'eau du Parc National de Moukalaba Doudou (sud-ouest du Gabon). Faunistic Entomology. 2017; 70:107-120
26. Kotchi BY, Edia OE, Konan KF, Kouassi n'gouan C, Diomandé D, Ouattara A. Spatial Distribution pattern of Freshwater Mollusks in Mé, Agnéby and Banco basins (Ivory Coast; West Africa). Bull. Env. Pharmacol. Life Sci. 2013; 2(12):146-151.
27. L'Hote Y, Mahé G, Some B, Triboulet JP. Analysis of Sahelian annual rainfall index from 1896 to 2000: the drought continues. Hydrol. Sci. J. 2002; 47:563-572.
28. Laurent D, Alain P. Synthèse sur la biologie des coques, Université U.C.O Bretagne Nord, Reserve Naturelle de la baie de Saint-Brieuc, 2008, 2-16.
29. Lebel T, Cappelaere B, Galle S, Hanan N, Kergoat L, Levis S, *et al*. Amma-Catch studies in the Sahelian region of West-Africa: an overview. AMMA-CATCH Spécial Issue. Journal of Hydrology. 2009; 375(1, 2):3-13.
30. Leroux L, Oszwald J, Ngounou Ngatchae B, Sebag D, Marie-Josée Penvenc, Servat E. Le bassin versant du Mayo-Tsanaga (Nord Cameroun): un bassin versant expérimental pour une compréhension des relations Homme/Milieu. Revue Française de Photogrammétrie et de Télédétection, 2013.
31. Lévêque C, Oberdorff T, Paugy D, Stiassny MLJ, Tedesco PA. Global diversity of fish (Pisces) in freshwater. Hydrobiologia. 2008; 595:545-567.
32. Lienou G, Sighomnou D, Sigha-Nkamdjou L, Mahe G, Ekodeck GE, Tchoua F. Système hydrologique du Yaéré (Extrême-Nord Cameroun), changements climatiques et actions anthropiques : conséquences sur le bilan des transferts superficiels. In: Hydrology of the Mediterranean and Semiarid Regions (Proceedings of an international symposium), Montpellier, France. 2003, 403-409.
33. Lietar J. Biologie et écologie des mollusques vecteurs de Bilharziose à Jodotville. Ann. Soc. Belg. Med. Trop. 1956; 36:919-1036.
34. Mofolusho OF, Benson O. Shell Morphology of Three Medical Important Tropical Freshwater Pulmonate Snails from Five Sites in South-Western Nigeria. International Journal of Zoological Research. 2015; 11:140-150.
35. Mustapha M, Yakubu H. Seasonal assemblage of macrobenthic invertebrates of a shallow tropical eutrophic African reservoir. Lake, Reservoirs and Ponds. 2015; 9:56-66.
36. Nalugwa A, Jorgensen A, Nyakaana1 S, Kristensen TK. Molecular phylogeny of *Bulinus* (Gastropoda: Planorbidae) reveals the presence of three species complexes in the Albertine Rift freshwater bodies. International Journal of Genetics and Molecular Biology. 2010; 2(7):130-139.
37. Ndassa A, Mimpfoundi R. The Mollusca inhabiting rice fields in northern Cameroon and their role as intermediate hosts for schistosomes. African Zoology. 2005; 40(2):223-232.
38. Ngounou Ngatcha B, Mudry J, Aranyossy JF, Naah E, Sarrot Reynault J. Apport de la géologie, de l'hydrogéologie et des isotopes de l'environnement à la connaissance des « nappes en creux » du Grand Yaéré (Nord Cameroun). Revue des sciences de l'eau/Journal of water science. 2007; 20(1):29-43.
39. Nouvelot JF. Hydrologie des Mayos du Nord Cameroun : Monographie de la Tsanaga. Cah O.R.S.T.R.O.M, série Hydrologie. 1973; 10:1- 93.
40. Ntonifor HN, Ajayi JA. Studies on the ecology and distribution of some medically important freshwater snail species in Bauchi state, Nigeria. Int. J. Biol. Chem. Sci. 2007; 1(2):121-127.
41. Olawusi-Peters OO. Composition and abundance of macro-benthic invertebrates in Owena reservoir, Ondo State, Nigeria. International Journal of Aquatic Science. 2017; 8(2):83-90.
42. Oliviera L, Scheiderman M. A Method of estimation of the density of aquatic snail population. Exp. Parasitol. 1956; 5:109-117.
43. Owojori OJ, Asalou SO, Ofoezie IE. Ecology of freshwater snails in Opa Reservoir and research farm ponds at Obafemi Awolowo University Ile-Ife, Nigeria. J. Appl. Sci. 2006; 6:3004-3015.
44. Poda JN, Sawadogo LI, Sellin B, Sanogo S. Dynamique des populations de *Bulinus truncatus rohlfsi* Clessin, 1886, dans le barrage de dyoro en one Nord Soudanienne du Bourkina Faso. Agronomie Africaine. 1996; 8(1):61-68
45. Robinson MW, Dalton JP. Zoonotic helminth infections with particular emphasis on fasciolosis and other trematodiases. Philos Trans R Soc Lond B Biol Sci. 2009; 364:2763-2776
46. Sarr A, Kinzelbach R, Diouf M. Specific diversity and ecology of continental molluscs from the lower Ferlo Valley (Senegal). Journal MalCo. 2011; 7:383-390.
47. Shailendra S, Sudha D, Rajendra C, Vibha D. Macro-invertebrate community diversity in relation to water quality status of Kunda River (M.P.), India. Discovery. 2013; 3:40-46.
48. Scholte P, Moritz M, Kari S. The involvement of nomadic and transhumance pastoralists in the rehabilitation and management of the Logone flood plain, North Cameroon, WAZA-LOGONE project, CES Leide, 1995, 36.
49. Sharma KK, Komal B, Minakshi S. Diversity and distribution of Mollusca in relation to the physico-chemical profile of Gho-Manhasan stream, Jammu (J & K). International Journal of Biodiversity and Conservation. 2013; 5(4):240-249.
50. Skelton PH, Swartz ER. Walking the tightrope: trends in African freshwater systematic ichthyology. Journal of Fish Biology. 2011; 79:1413-1435.
51. Slootweg RE, Van Rhijn JA, Van Schijndel MJ, dikstra, Colenbrander AC. A longitudinal study of snail intermediate host of trematode parasite in the Benue Valley of North Cameroon. Journal of Medecinal and

Applied Malacology. 1993; 5:45-49.
52. Subba BR. Molluscan checklist of Ghodaghodi Tal area, Kailali District. Our Nature. 2003; 1:1-2.
53. Tadelle T, Worku T. The prevalence and economic significance of bovine fasciolosis at Jimma, Abattoir, Ethiopia, The Internet Journal of Veterinary Medicine. 2007; 3:1-15.
54. Tedonkeng P. Stratégie d'élevage de saison sèche dans la Région de Mindif, Plaine du Diamaré, Nord Cameroun. Tropicultura. 1993; 11(1):29-33.
55. Ugwumba AAA. Composition, Distribution and Diversity of Benthic Macroinvertebrates of Ona River, South-west, Nigeria. European Journal of Zoological Research. 2012; 1:47-53.
56. Van Eeden JA, Brown DS, Oberholzer G. The distribution of freshwater molluscs of medical and veterinary importance in southeastern Africa. Annals of Tropical Medicine and Parasitology. 1965; 59:413-424.
57. Vassiliadès G. Capacité de résistance à la sécheresse de la limnée *(Lymnaea natalensis)*, mollusque hôte intermédiaire de *Fasciola gigantica*, au Sénégal. Revue d'Elevages et de Médecine vétérinaire des Pays tropicaux. 1978; 31:57-62.
58. Watson. Ecology and distribution of *Bulinus truncatus* in Middle East: with comments on the effect of some human activities in their relationship to the snail host on the incidence of haematobia in the Middle East and Africa. Bull. Wld. Hlth. Org. 1958; 18:833-894.
59. Wendelin Moser, Helena Greter, Christian Schindler, Fiona Allan, Bongo NR, Ngandolo, *et al*. The spatial and seasonal distribution of *Bulinus truncatus*, *Bulinus forskalii* and *Biomphalaria pfeifferi*, the intermediate host snails of schistosomiasis, in N'Djamena, Chad. Geospatial Health. 2014; 9(1):109-118.
60. WHO, La Schistosomes (Bilharziose). WHO/WSH/ZZ/DFS, Genève, 2010.
61. Zaghloul Noura MRM, Grabner D, Faten AMM, Mohamed, Hameed AA Sabry, Bernd Sures. Effect of some Physico-Chemical Parameters on Abundance of Trematode Snails in Fayoum Governorate, Egypt. Fayoum Drinking Water and Sanitation Company, Fayoum, Egypt. 2013, 1-8.
62. Zieba FW, Ganota B. Territoires agropastoraux et accès à l'eau en milieux sahélien camerounais. In Colloque national : la politique sectorielle du pastoralisme au Tchad, quelle orientation, Ndjamena Tchad, 2010, 1-180.