Impact of Lakes on Parasite Infestation in Populations of the Far-North Cameroon

Hadidjatou Bouba[1*]; Augustin Siama[2]; Eteme Enama Serge[3]; Njan Nlôga Alexandre- Michel[4]

[1] University of Ngaoudere, Faculty of Science, Department of Biologie Science
[2]University of Ngaoudere: ESMV
[3]University of Yaoundé
[4]Faculty of Science

Corresponding Autor: Hadidjatou Bouba[1*]

Publication Date: 2025/08/02

Abstract: In order to assess the impact of the lake on the parasitic infestation, an epidemiological study on blood, urinary and intestinal parasites was conduct in three localities in the far north of Cameroon (Ma .ga, Mokolo and Maroua). To do this, a sample of 1,080 individuals were surveyed and parasitized. Thick drops and blood smears were performed for the examination of blood parasites, centrifugation technique for the examination of parasites in urine and thin film technique for stool examinations. The data obtained showed that the populations of the lake areas (Maga and Mokolo) are more engaged in fishing and farming occupations than those of the non-lake localities (Maroua). *Plasmodium falciparum* infestation is greater in Maroua especially during the rainy season (73.64%), while *Plasmodium malariae* affects more populations of Maga especially during the rainy season (60%). The majority of helminth infestation occur frequently in lake waters. The populations of Mokolo and Maga are also infested with *Schistosoma mansoni* with respective rates 62.50% and 68.88%. The infestation of *Entamoeba histolytica* is higher in Mokolo (39.58%) and Maroua (39.02%). The infestation of *Schistosoma haematobium* is greater in Mokolo (21.81%) followed by the populations of Maga (15.28%). The prevention and control of blood, intestinal and urinary parasitosis in Far North Cameroon involves awareness and education of populations. This will allow the adaptation of more responsible behaviors through the practice of good personal, community and environmental hygiene.

Keywords: *Investigation, Parasitic Examination, Lakes, Parasitic Infestation, Far-North Cameroon.*

How to Cite: Hadidjatou Bouba; Augustin Siama; Eteme Enama Serge; Njan Nlôga Alexandre-Michel (2025) Impact of Lakes on Parasite Infestation in Populations of the Far-North Cameroon. *International Journal of Innovative Science and Research Technology*, 10(7), 2728-2741. https://doi.org/10.38124/ijisrt/25jul1403

I. INTRODUCTION

Water sources have always influenced human activities in surrounding cities. These activities are often varied and essential for local people. Water is essential for life and the activities of living beings, covers about 70% of the earth's surface, but only 3% of this so-called continental water is usable by the 7 billion inhabitants of the planet (Baechler, 2017). However, its uneven geographical distribution disadvantages some regions, especially arid areas. Water resources, such as lakes, are treasures for the local population, both for their daily needs and for their economic activities. However, these water points can also serve as potential hosts for the development of bacteria, parasites and their vectors, as well as intermediate hosts responsible for many diseases. Their attendance contributes to the spread of various pathologies, especially in developing countries (Nanfack *et al.*, 2014).

In Cameroon, many resources (Wirmvem *et al.*, 2013) such as lake waters contribute to agricultural activities and fishing (Wirmvem *et al.*, 2013). However, access to water remains a problem (Djuikom *et al.*, 2011; Wirmvem *et al.*, 2013), which promotes disease transmission in humans and animals (Garcia, 2013). Despite the importance of agricultural and fishing activities, which require people to come into direct contact with lakes, very few studies have looked at the impact of this proximity on the health of riparian populations. Our study aims to assess this impact in order to better understand the health risks associated with the cohabitation with lakes.

The use of lake waters remains associated with significant risks to populations. However, the level of endemicity of parasitic diseases varies from one area to another. In order to assess the impact of these lakes on parasitic infestation within populations, we will first

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jul1403

determine the risk behaviors that favor parasitic infestations among populations living in lacustrine areas compared to those living in non-lacustrine areas on the other hand, compare the prevalence of potential parasitoses between populations in lacustre and non-lacustre areas.

II. MATERIALS AND METHODS

The Far North region of Cameroon is a Sudanese-Sahelian zone located at 400 m altitude between latitude 10° and 13° north and longitude 13°15' and 15°45' east. It covers approximately 34,263 km2 between Nigeria to the west and Chad to the east (Kuété *et al.,* 1993; DSCN, 2002). The climate is tropical of Soudano-Sahelian type characterized by a short rainy season from June to October and a long dry season from November to May. Precipitation ranges from 500 to 900 mm per year with average between 750 and 800 mm (DSCN, 2002). The daily average temperature is about 28°C can reach peaks of 45°C between March and May. Thermal amplitudes sometimes reach 20°C (Kuété *et al*. 1993; DSCN 2002). Winds are usually strong, with the strongest occurring during seasonal changes, at the end of the dry period and the onset of rainfall (Boutrais 1984; Kuété *et al.,* 1993).

To investigate the risk behaviors present in populations, a household survey was conducted by using questions drawn on a survey sheet presented below and digitized using software developed by KoboCollect. These interviews aim to know the socio-economic profile of the target populations on the other hand have an idea about the risk behaviors adopted in these populations on a daily basis.

➢ *Sample Collection and Reading*

- *Blood*

A quick, dry shot with a vaccinostyle was applied to the subject's ring after disinfecting and then pressing the finger to remove the first drop of blood with dry cotton. A large drop of blood was deposited 1 cm from the range of a blade. At the end, dry cotton was applied at the point of the bite for 2-3 minutes according to the techniques used by WHO (1993).

After sampling, the drop of blood was spread on the blade in a circular manner using a corner of a lamella for the realization of the thick drop. This drop was dried in the shade for 15 minutes away from insects and then covered with a pipette of Giemsa solution diluted to 10% in distilled water and left to rest for 15 minutes. Subsequently, the opposite side of the blade was rinsed slightly with tap water and then allowed to dry in the shade.

Once dried, a drop of immersion oil was place on the blood drop and observed by microscope at the X100 lens.

- *Stools*

Small plastic bottles, closed, transparent and sterile, were labelled and given to subjects one day prior to sampling. These vials containing about 10 grams of stool taken very early in the morning were packed in a small plastic bag are collected from 8 h 00 am. Samples are then sent to each local District Hospital in a cooler for analysis.

The stools were examined macroscopically and microscopically. The macroscopic examinations were done by observing with the naked eye the appearance, color, consistency and possible presence of blood. For microscopic examination, two drops of physiological water are placed on a clean specimen-holder blade using a micropipette. Then a patch of fecal matter was taken by spatula and diluted in this water. The whole is then covered with a lamella so as to obtain a layer thin enough to be transparent and allow the search of eggs, cysts and larvae. The observation was made using brand photonic microscope gradually ranging from the X10 lens to the X40 lens.

- *Urine*

The transparent plastic containers were labeled and given to each subject one day prior. A sample of at least 10 ml of urine was collected at the end of urination in the bottle very early in the morning. Each bottle was wrapped in a small plastic bag and collected at 8:00 a.m. The samples were quickly transported to the District Hospital in each locality for analysis.

Urine examination was subject to macroscopic and microscopic observation. Macroscopic observation allowed us to detect cases of apparent hematuria. Microscopic observation allowed us to assess the possible presence of *S. haematobium* eggs. Ten (10) mL of urine was collected from the bottom of the container and poured using a pipette into a hemolysis tube and then centrifuged for 3 minutes at 5000 rpm using an electric centrifuge. The collected pellet is examined between slide and coverslip under an OLYMPUS electron microscope, first with the X10 objective for image perception, then with the X40.

- *Statistics*

To analyze the data obtained, we used Microsoft Excel 2013 software to extract the prevalence of population occupations, the prevalence of the various behaviors observed, and the prevalence of infestations for each parasitic disease encountered. We then used SPSS software, including the Kruskal-Wallis test, to compare these different prevalences. The recorded percentages were compared using the Schwartz formula (1993) at the 5% threshold.

III. RESULTS AND DISCUSSION

A. Socio-Economic Profile of the Population

The recorded results show the distribution of respondents according to their profession in the Far North of Cameroon (Figure 1). Four hundred individuals from the target population were surveyed in each area. These respondents are grouped into four professions.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jul1403

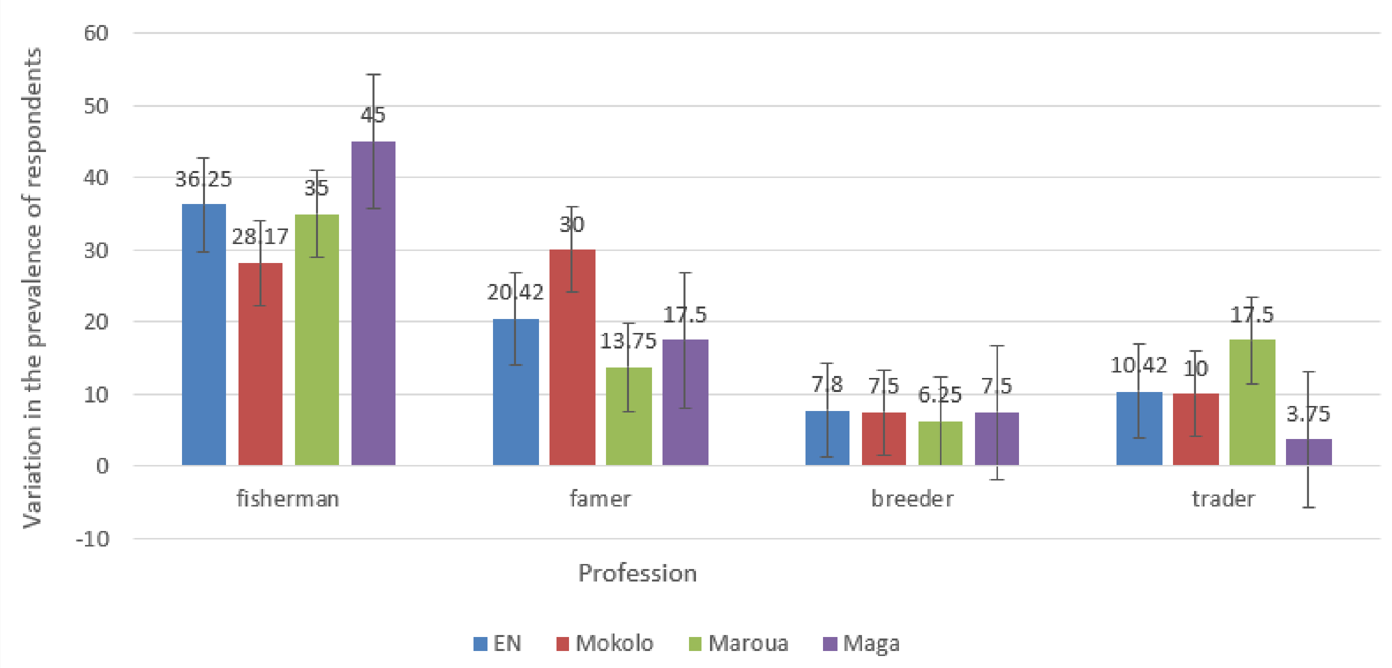


Fig 1 Distribution of Respondents by Occupation in the Far North of Cameroon
Legend: EN: Far North

This figure shows that there are significantly more men working as fishermen in Maga than in Mokolo or Maroua (p=0.0002). Analysis between the different areas shows that among fishermen, there are no significant differences in Maroua-Maga (Z=5.03), Mokolo-Maga (Z=8.69) and Mokolo-Maroua (Z=3.61). In the case of men working as farmers, the rate is significantly higher in Mokolo than in Maga and Maroua (p=0.006). Analysis of the results also shows that among livestock farmers, there is no significant difference in the three areas (p=0.085). On the other hand, among traders, the rate of men in Maroua is higher than that of Mokolo (Z=5.37) and Maga (Z=11.21). The results also show that the behavior of individuals varies in the three study areas (Figure 2).

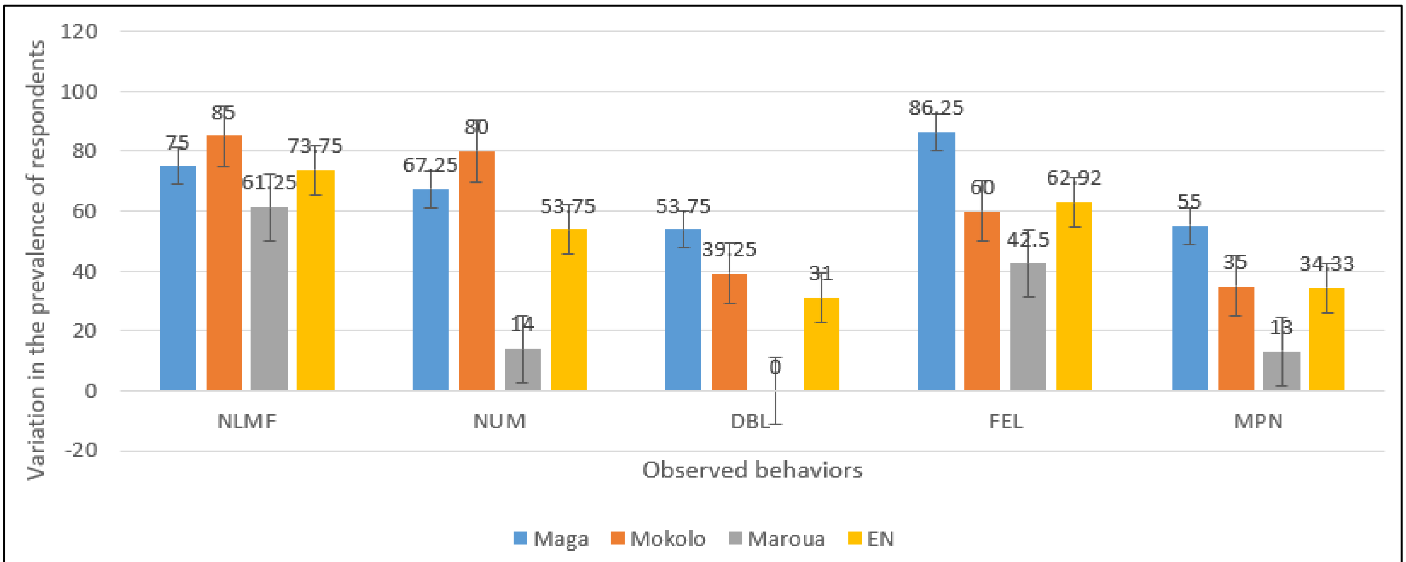


Fig 2 Variation in the Prevalence of Respondents according to Behavior in Far North of Cameroon
Legend: NLMF: Not Washing Hands and Fruits; NUM: Not using Mosquito Nets; DBL: Defecation at the Edge of the Lake; FEL: Frequent use of Lake Waters; MPN: Walking Barefoot

From these results, we note that the number of men who do not wash their hands before eating and do not wash fruit before eating show a significant difference in the three areas (p = 0.007). Particulary, we note that there is a difference between individuals living in Maroua and Maga (z = 2.27). This could be explained by the fact that the population of Maga lives by the lake while that of Maroua is far from the lakes. Regarding the use of mosquito nets, there is a significant difference between the three (3) areas (p = 0.004). The number of inhabitants who use mosquito nets is lower in Maroua than in Maga (z = 2.27) and in Mokolo (z = 7.75). This could be explained by the fact of promiscuity, ignorance

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jul1403

and lack of awareness among the populations. The number of residents who defecate near lakes is higher in Maga than in Mokolo (z = 2.18). This figure could be explained by the fact that Maga residents, who are constantly fishing, are always present around water. This observation is also true for populations who frequent the water (z = 2.50). Maga residents also habitually walk barefoot compared to the residents of Mokolo (z = 3.07) and Maroua (z = 5.89).

The distribution of occupations in Maga can be explained by the presence of a fish-rich lake and also the favorable development of aquaculture such as rice cultivation described by Yelnik *et al.* (1982). The results obtained in Mokolo suggest that in addition to the presence of lakes (large and small dams), the climate and rainfall are suitable for agriculture, favored by its position at altitude (L'hôte, 2000). The fact that the population of Maroua is more involved in trade than in fishing would be due on the fact that the promotion of the development of small and medium-sized enterprises is booming and dried fish constitutes a special diet of its inhabitants. These results are consistent with those of Saotoing *et al.* (2019) who found more farmers than other professions in Mokolo. These results show that the populations present around the lakes are exposed to a high risk of infestation by gastrointestinal diseases (Maga and Mokolo) compared to Maroua. Fishing and agriculture are risky professions where the cultivation of the land multiplies contact with protozoa and geohelminths (Saotoing *et al.*, 2019). All these behaviors with a high risk of infestation would result from promiscuity, ignorance and a lack of awareness among the populations by the competent services (Ayadi *et al.*, 1991 in Tunisia; Saotoing *et al.*, 2019 in Mokolo; Penali *et al.*, 1993 and Menan *et al.*, 1997 in Ivory Coast).

B. Parasitic Variations

➢ *Blood*

- *Seasons Variations*

During the various investigations in the three study areas, it appears that Plasmodium is the only parasite present in the blood. These are *Plasmodium falciparum* and *Plasmodium malariae* (Figure 3).

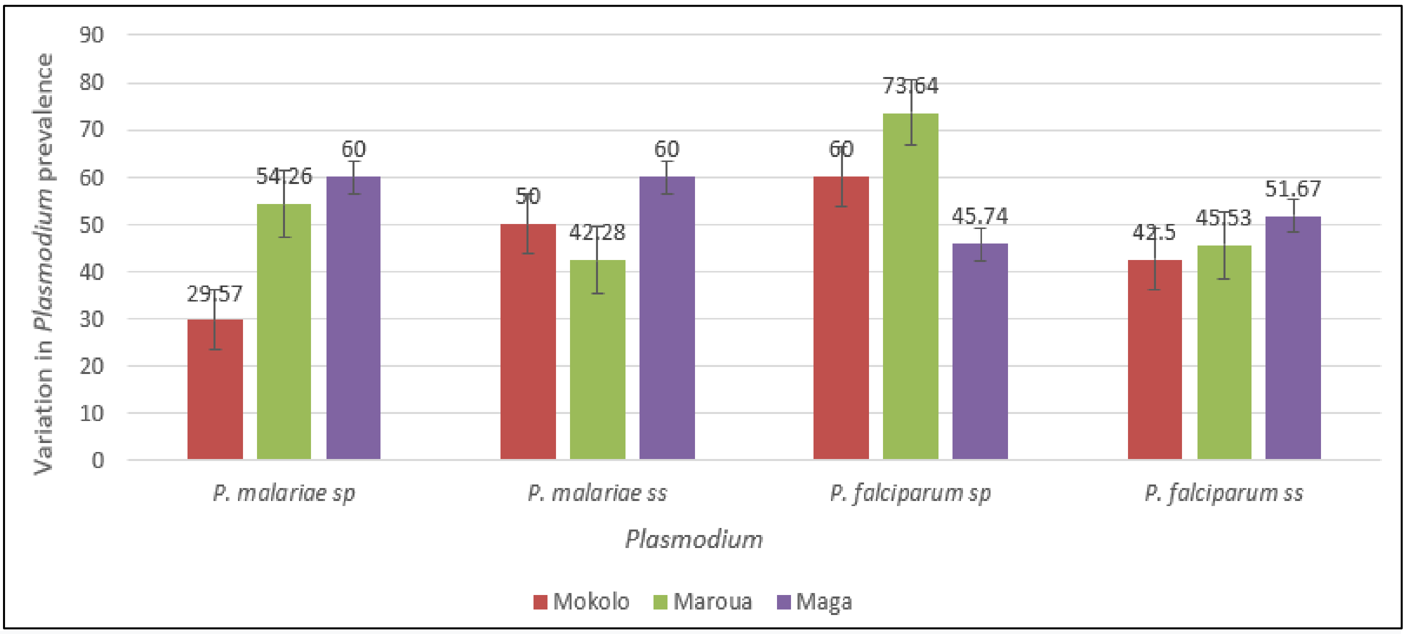


Fig 3 Variations in the Prevalence of *Plasmodium malariae* and *Plasmodium falciparum* according to the Seasons
Key: SP = Rainy Season; SS = Dry Season

It emerges from this figure that the prevalence of *Plasmodium falciparum* evaluated in these three study areas are significantly higher in the rainy season (ddl = 5; ndl = 1; p = 0.0005) compared to those obtained in the dry season. However, in the rainy season, the prevalence of *Plasmodium falciparum* infestation obtained in Maroua is higher than that in Maga (z = 8.40) as well as that obtained in Mokolo (z = 4.14). While in the dry season, the infestation in Mokolo is lower than that in Maga (z = 2.61).

It is also evident from this figure that the prevalence of *P. malariae* shows a slight variation in the infestation rate during different seasons. However, these differences are not significant (ddl = 5; p = 0.126; alpha = 0.05) (Fig. 3). During rainy season, the variations in *P. malariae* infestations between the study areas show that in the rainy season, Mokolo is the least infested area with a significantly lower rate than Maroua (z = 8.10) and Maga (z = 4.54). While during the dry season, Maga is the most infested area than Maroua (z=2.41) and Mokolo (z=5.10).

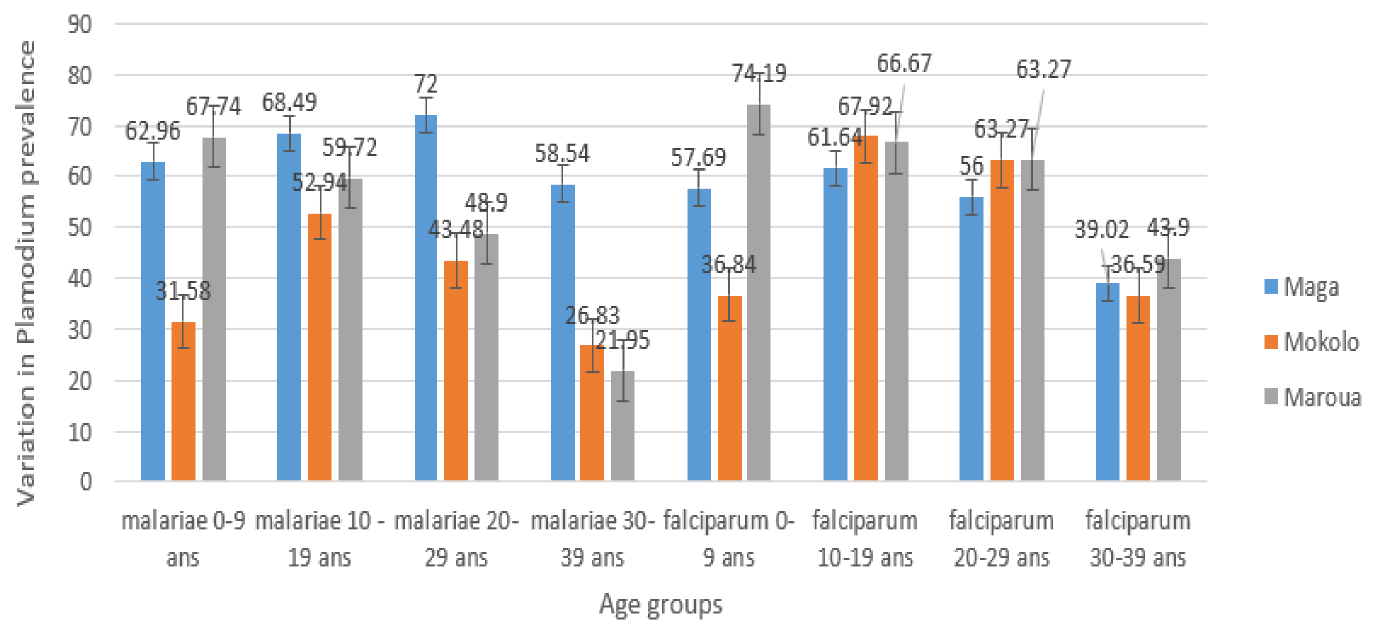
These results can be explaine depending on the study areas, as in Maroua, by the increase in temporary breeding sites during the rainy season, favoring the development of Anopheles mosquitoes, vectors of disease transmission (Delmont 1982; Atangana, 2010).

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jul1403

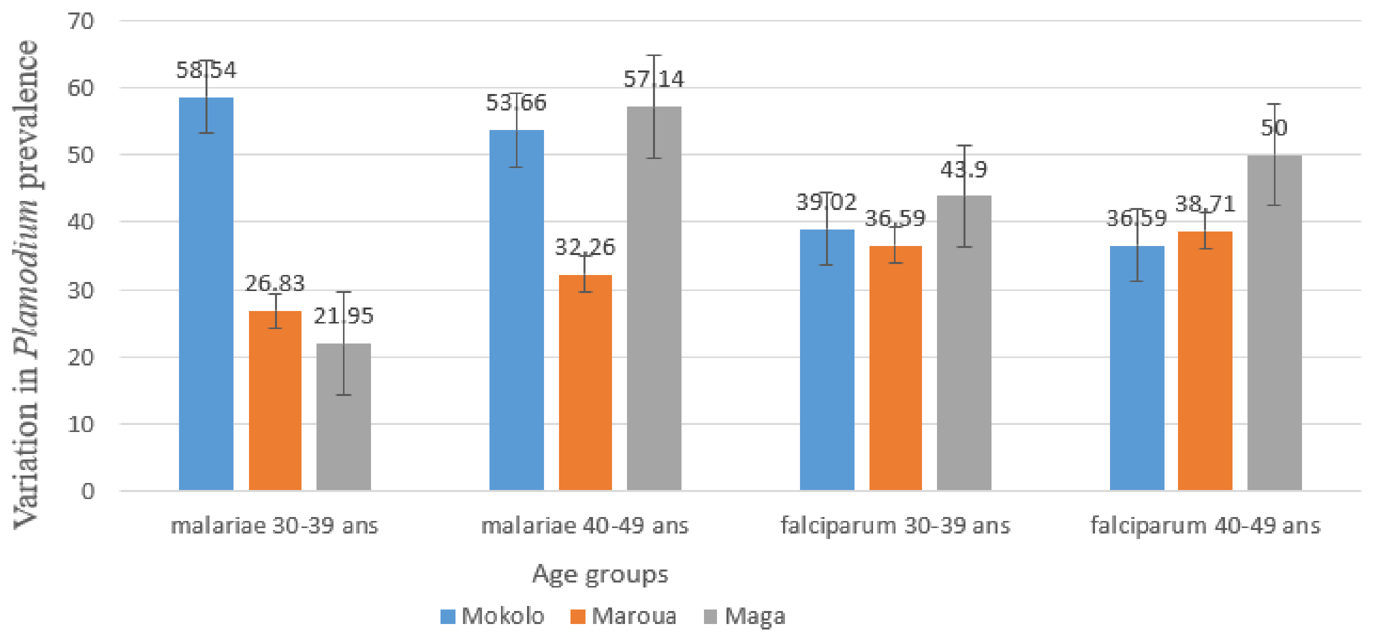
Other authors also found differences between dry and rainy seasons (Josse *et al.*, 1987) in the Logone plain. The maintenance of larval breeding sites could also maintain the level of parasite transmission while their destruction would have the opposite effect. Indeed, the change in the environment that affects the multiplication of vectors and consequently the level of parasite transmission would have a direct impact on local prevalence in the dry season (Delmont, 1982). Several studies have shown that A. gambiae and A. funestus are the main vectors of malaria in the region (Mouchet and Rageau, 1964; Couprie *et al.*, 1985; Kollo *et al.*, 2001; Chouaibou *et al.*, 2006). The distribution of these vectors would be linked to changes in the environment. More recently, the capture in the Far North region (Atangana, 2010), i.e. 954 *Anopheles* including 631 (66.1%) during the rainy season and 323 (33.9%) during the dry season, class A. gambiae in the lead with (64.2%); *A. funestus* (32.6%); *A. rufipes* (2.3%) and *A. pharoensis* (1%).

- *Variations Depending on Age*

The recorded results show that the prevalence of *P. falciparum* and *P. malariae* varies according to age in the areas of Maga, Mokolo and Maroua in the Far North of Cameroon (Figure 4).



(a)



(b)

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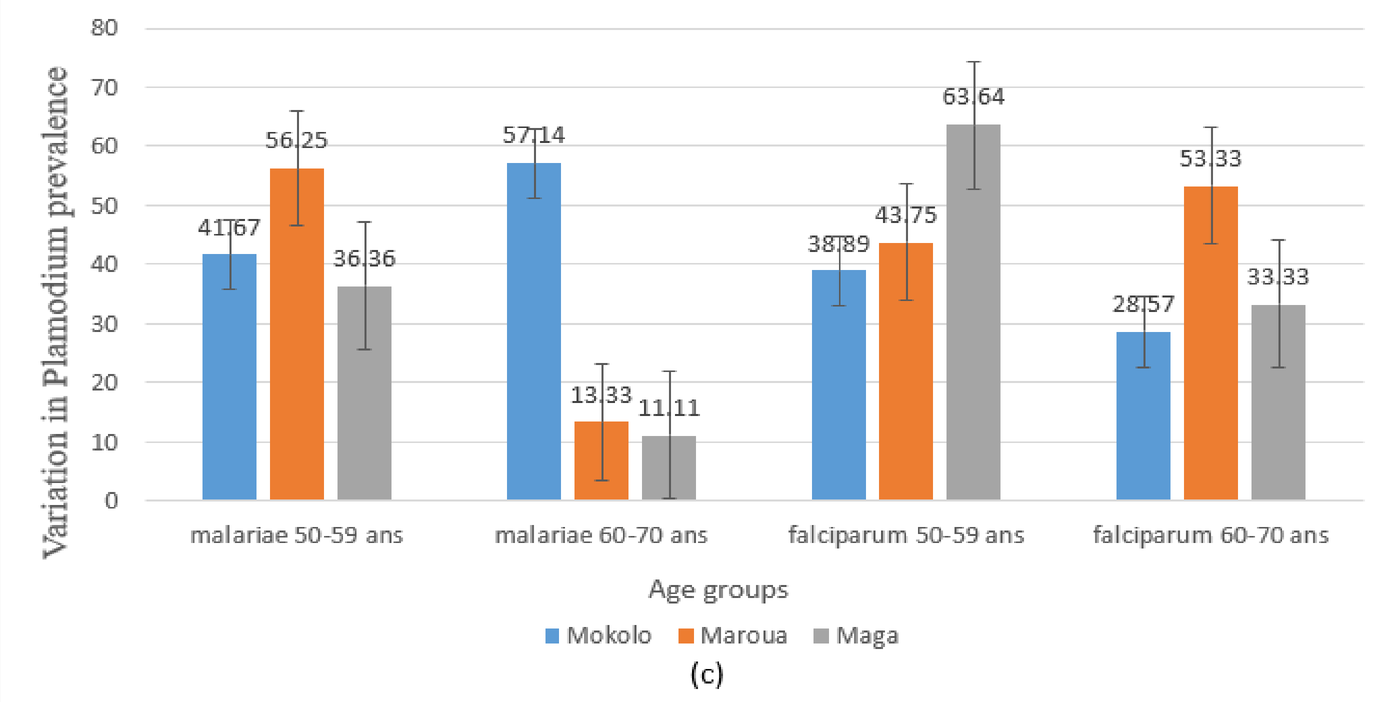

Fig 4 Variations in the Prevalence of *Plasmodium malariae* and *Plasmodium falciparum* according to Age.

From this figure we observe a significant variation of *P. falciparum* infestations between age groups (ddl= 20; p= 0.019; alpha=0.05) regardless of the area. In the context of *P. malariae* this variation is highly significant (ddl= 20; p= 0.00001; alpha=0.05) between age groups in all study areas.

We note that people aged 0 to 9 years in the Mokolo area are the least infested with *P. malariae* compared to those in Maroua (z=4.84) and Maga (z=4.46); while among people aged 10-19 years, the infestation rate in these areas does not show any significant difference (z=1.80; z=0.85; z=0.97). *P. malariae* infestation among individuals aged 20-29 years (Figure 4a) and 30-39 years (Figure 4b) varies between the 3 areas with more infested in Maga compared to Mokolo (z=3.40; z=4.93) and Maroua (z=2.66; 5.85) (Figure 4b). In the Mokolo area, individuals aged 60-70 years are the most infested compared to Maga (z=7.45) and Maroua (z=7.91) (Figure 4c). It also appears that the rate of *P. faciparum* infestation among people aged 0-9 years is significantly higher in Maroua compared to that of Mokolo (z=4.71) (Figure 4a); while the difference in infestations is stationary and not significant in the three areas for people aged 10-19 and 20-29 years (Figure 4a), The same observation was made among people aged 30-39 and 40-49 years (Figure 4b). People aged 50-59 are more infested in Maga than in Maroua (z=2.16), while people aged 50-59 are significantly more infested in Maroua than in Mokolo (z=3.18) (Figure 4c).

These results can be explained by the fragility of immunity in people aged 0 to 9 years and 10-19 years against *P. falciprum* and *P. malariae*, compared to adults who would be much more protected. In endemic areas, age can condition the maturity of the immune system (Hannet *et al.*, 1992), the prevalence of Plasmodial infestations decreases with the increase in the level of immunity (Rogier *et al.*, 2009).

In each area, people aged 0-9 and 10-19 are highly more infected than other age groups. This situation can be explained by the fragility of immunity in people aged 0-9 and 10-19 years with respect to *P. falciprum*, compared to adults who would be much more protected. In endemic areas, age can condition the maturity of the immune system (Hannet et al., 1992; Rogier et al., 2009), the prevalence of *Plasmodial* infections decreases with the increase in the level of immunity.

- *Sex-Dependent Variation of Parasites*

The results present the variation in the prevalence of *Plasmodium falciparum* and *Plasmodium malariae* according to sex in Maga, Mokolo and Maroua (Figure 5).

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jul1403

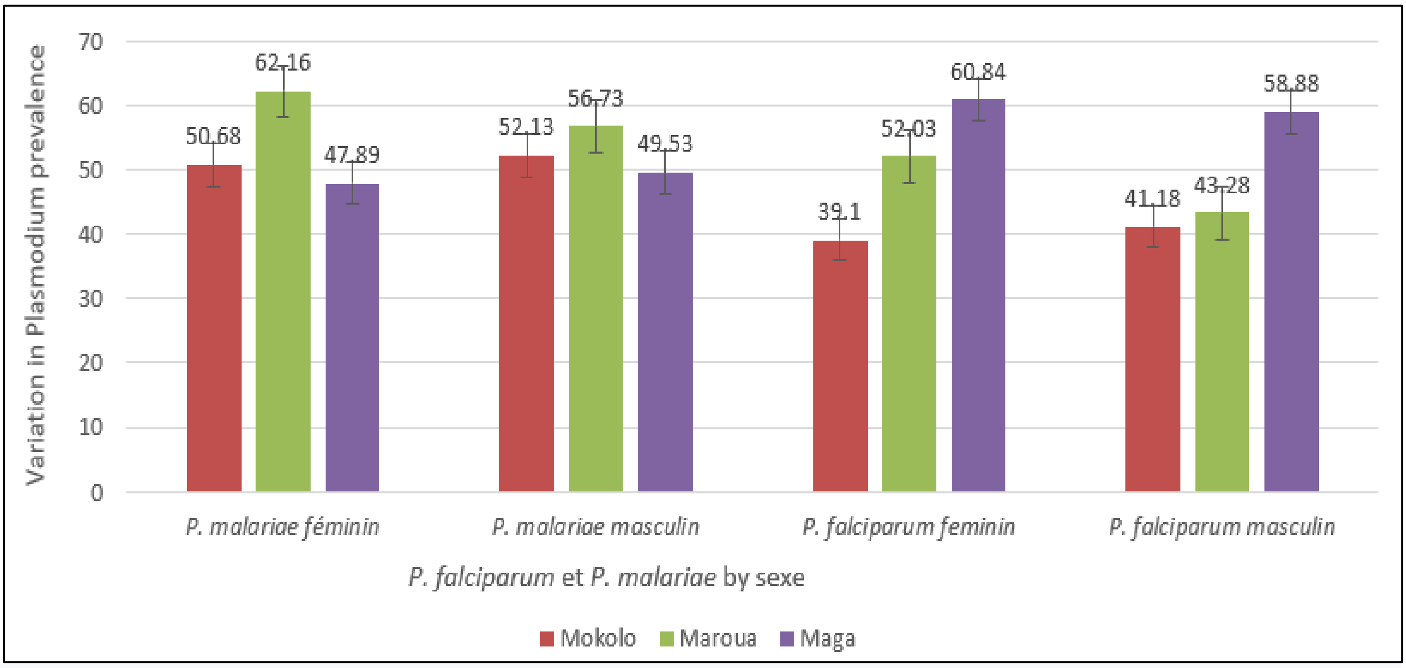

Fig 5 Prevalence of *Plasmodium falciparum* and *Plasmodium malariae* by Sex

This figure shows that females are infected with *P. falciparum* as males with a non-significant difference (ddl=5; p=0.333; alpha=0.05). It can also be noted that *P. malariae* infestation affects females and males equally (ddl=5; p=1.32; alpha=0.05) (Fig. 5). In females, *P. falciparum* infestation is higher in Maroua, unlike in Mokolo (z=2.28); while the variation in infestations in males is non-significant. *P. malariae* infestation in females in Maga is significantly higher than in Mokolo (z=3.70) and Maroua (z=2.52); As well as among males, infestation is higher in Maga compared to Maroua (z=4.47) and Mokolo (z=5.08).

Variations in the rates of different species in the study areas could be explained by the fact that women and men engage in virtually the same activities. Women may have a higher risk when they are pregnant. This is because their immunity to malaria decreases after the first three months of pregnancy, and they become more vulnerable (Diagne *et al.*, 2000; Rogier *et al.*, 2009; Pradines *et al.*, 2010). The difference between men and women in Maroua may be explained by the fact that in urban areas, women and men no longer engage in the same activities. Indeed, women are at risk, especially when they are pregnant.

➢ *Variation of Parasites in Stool*

• *Prevalence According to Seasons*

Shistosoma mansoni and *Entamoeba histolytica* are the two parasites found in the stools of residents of these study areas. The results show the prevalence of *Schistosoma mansoni* according to season (Figure 6).

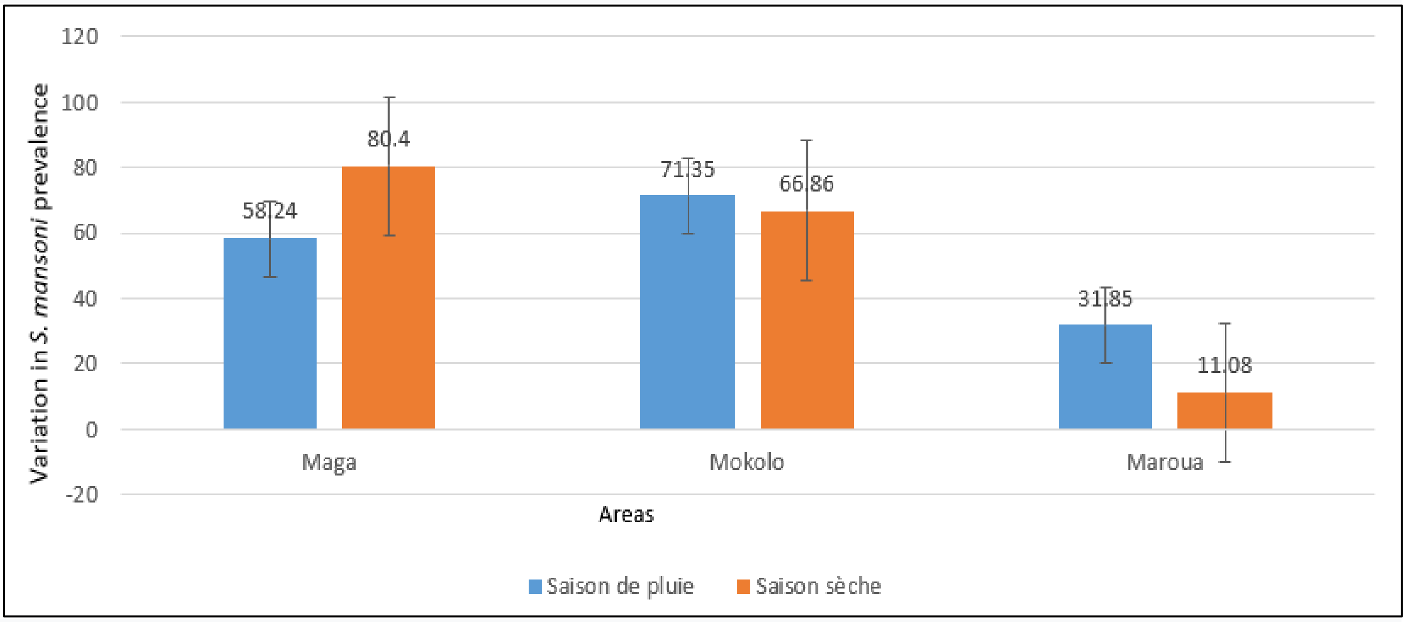

Fig 6 Prevalence of *Schistosoma mansoni* according to Season in some Areas

It is clear from this figure that, overall, the *S. mansoni* infestation rate is higher during the rainy season than the dry season (ddl= 5; p=0.000; alpha=0.05). The *S. mansoni* infestation rate in the rainy season is higher in Mokolo as compared to that of Maroua (z=52.52); while during the dry season, this infestation rate is higher in Maga as compared to Mokolo (z=27.40) and Maroua (z=8.54).

The proliferation of molluscs in Mokolo and Maroua due to the rainy season and the occurrence of floods that bring molluscs close to habitats, favors the transmission of the disease by these hosts. While in Maga, transmission is due to the frequentation or use of waters of the infested lake (Nanfack *et al.*, 2014). These results are higher than those obtained by Menan *et al.* (1973) in Ivory Coast, Raccurt *et al.* (1987) who found a prevalence of 27.80% in Adamaoua and Saotoing *et al.* (2019) at the Mokolo dam.

The recorded results present the prevalence of *Entamoeba histolytica* according to seasons and area (Figure 7).

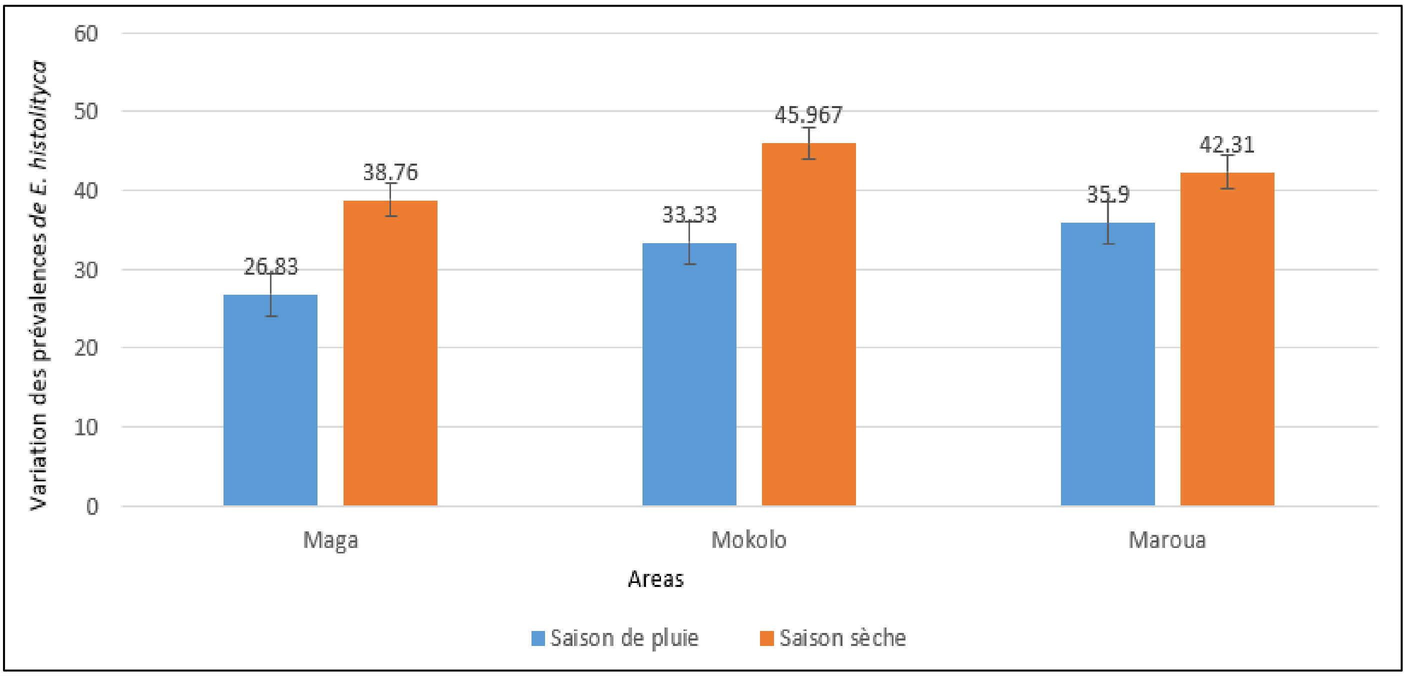

Fig 7 Prevalence of *Entamoeba histolytica* according to Seasons

It appears from this figure that overall, the infestation rate of *Entamoeba. histolityca* shows no significant variation (ddl= 5; p=0.481; alpha=0.05) between the dry season and the rainy season. These results reveal that during the rainy seasons the populations of Maroua are more infested than those of Maga (z=9.33) and Mokolo (z=2.37). However, during the dry season the infestation rate of *E. histolityca* in Mokolo is significantly higher than that noted in Maroua (z=9.56).

These results could be due to the scarcity of drinking water that remains a persistent problem throughout the year. People have to walk for kilometers to get supplies at watering holes that are sometimes disputed with animals (MINEP, 2010; Djuikom *et al.*, 2011; Wirmvem *et al*., 2013).

The variations in prevalence depending on the areas and seasons could be explained by factors that limit the transmission of *E. histolytica*. Indeed, the abundance of water in these areas would have a limiting effect on the transmission of *E. histolytica*, whereas in the non-lake area of Maroua, the scarcity of water would favor transmission. And these rates are higher than that of 24.4% obtained in the Buea health district in Cameroon (Mbuh *et al.*, 2010). Population density and contact with unsanitary structures could also justify the increase in this infestation rate. This activity could also increase the infestation rate due to the long journey women have to make to collect water (MINEP, 2010). Poor domestic or personal hygiene can often increase the infestation rate or reduce to zero the public health benefits that could be derived from better environmental sanitation (Françeys, 1995). In Maroua, the increase in water shortages has a direct impact on the health status of the population and causes an increase in the incidence of many diseases due to poor hygiene (Delepière, 2004). Similarly, good personal hygiene implies that a sufficient quantity of water is available (Delepière, 2004; Curtis, 2009). Furthermore, different age groups, men and women are exposed to the same level of transmission, depending on whether they belong to the same area.

- *Prevalence by Age*

The results show that the prevalence of *Shistosoma mansoni* varies according to age in some areas (Figure 8).

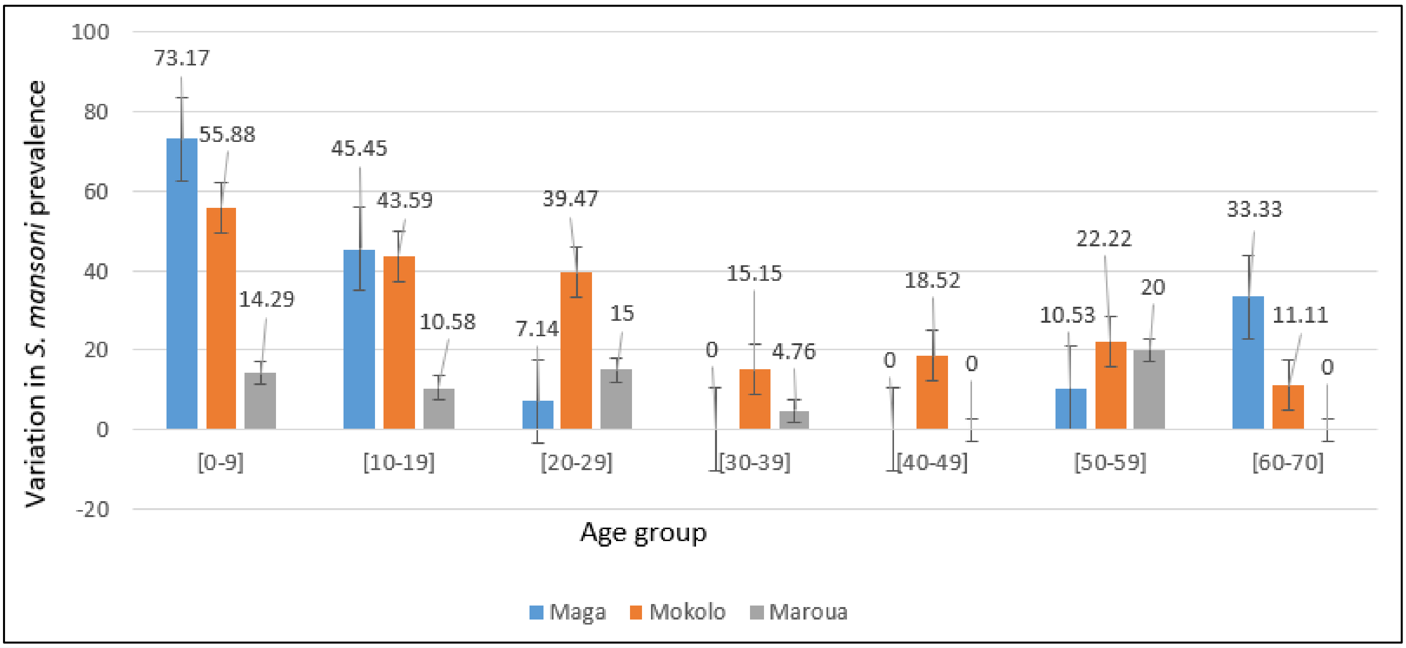

Fig 8 Prevalence of *Schistosoma mansoni* according to age in some Areas of the Far North of Cameroon

It is clear from this figure that there is a highly significant difference (ddl = 20; p = 0.00001; alpha = 0.05) in the infestation rate between the different age groups. We also note from this figure that, for the infestation rate among individuals aged 0-9 years, Mokolo is more infested than Maroua (z = 7.21) and Maroua is more infested than Maga (z = 7.90). For individuals aged 10 to 19 years, the infestation rates are higher in Mokolo than in Maroua (z = 7.36) as well as in Maga compared to Maroua (z = 7.47). For subjects aged 20 to 29, the highest infestation rate is in Mokolo and the lowest is in Maga with a significant difference between Maga and Maroua (z = 4.73). Individuals aged from 30 to 39, no inhabitant is parasitized in Maga, on the other hand in Mokolo, the infestation rate is higher than in Maroua (z = 6.54). Subjects aged 40 to 49 in Maroua and Maga, there are no infested individuals. On the other hands in Mokolo, the infestation rate is 18.52%. For individuals aged from 50 to 59, the lowest infestation rate is in Maga with 10.53%, with a significant difference compared to Maroua (z = 4.20%). We also note this for subjects aged from 60 to 69, where the individuals present in Maga are not infested.

The high frequencies in younger subjects could be explained by These results would be due to the fact that hygiene rules are ignored or not respected among young adults. In Maga and Mokolo, young adults generally walk barefoot and regularly visit the lake (Menan *et al.* 1997; Saotoing *et al.*, in 2019).

The results recorded in this study compared to *Entamoeba histolytica* according to age (Figure 9).

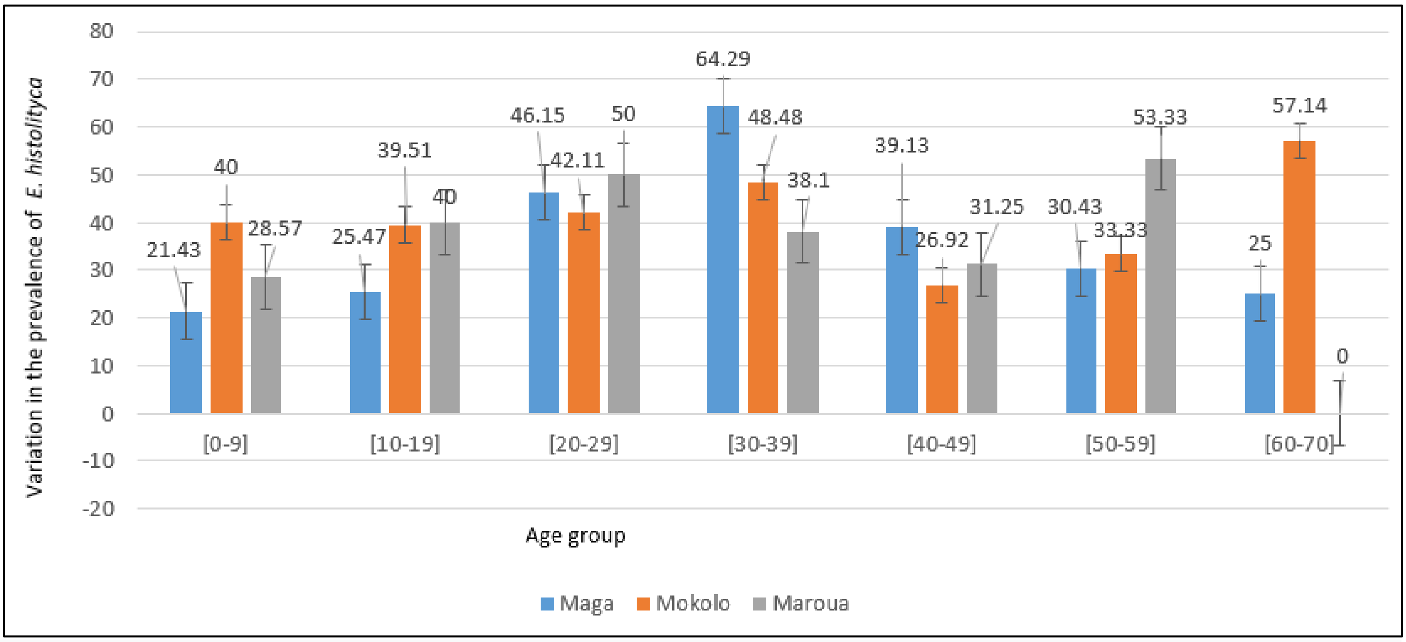

Fig 9 Prevalence of *Entamoeba histolytica* according to Age

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jul1403

It emerges from this work that there is no significant difference overall between the different infestation rates in the age groups (ddl=20; p=0.199; alpha=0.05). We also note that the infestation rate among individuals aged from 0-9 years, the highest infestation rate is found in Mokolo with 40%. This rate is significantly higher than that of Maga (z = 4.09) and Maroua (z = 2.33). While among people aged from 10-19 years, the infestation rate is higher in Maga compared to Maroua (3.06) and Mokolo (z=3). Individuals aged from 30-39 years are the most infested in our age groups with individuals from Maga the most infested compared to Maroua (z=3.50) and Mokolo (z=1.97). Among people aged from 50-59, the infestation rate is higher in Maroua than in Maga (z=3.73) and Mokolo (z=3.18), for those aged from 60-70 the infestation is non-existent in Maroua.

The variations recorded in the different areas in relation to the age of individuals could be explained by the cultures, in certain areas young people consume all food without washing their hands or even leaving the food consumed. Thus the direct and regular consumption of food such as hard-boiled eggs, fruits and vegetables like sweetcorn or mangoes offered by street vendors to young adults during their hours of service (Delepière, 2004).

- *Prevalence of Infestations according to Sex*

The results show that the prevalence of *Schistosoma mansoni* varies according to sex (Figure 9).

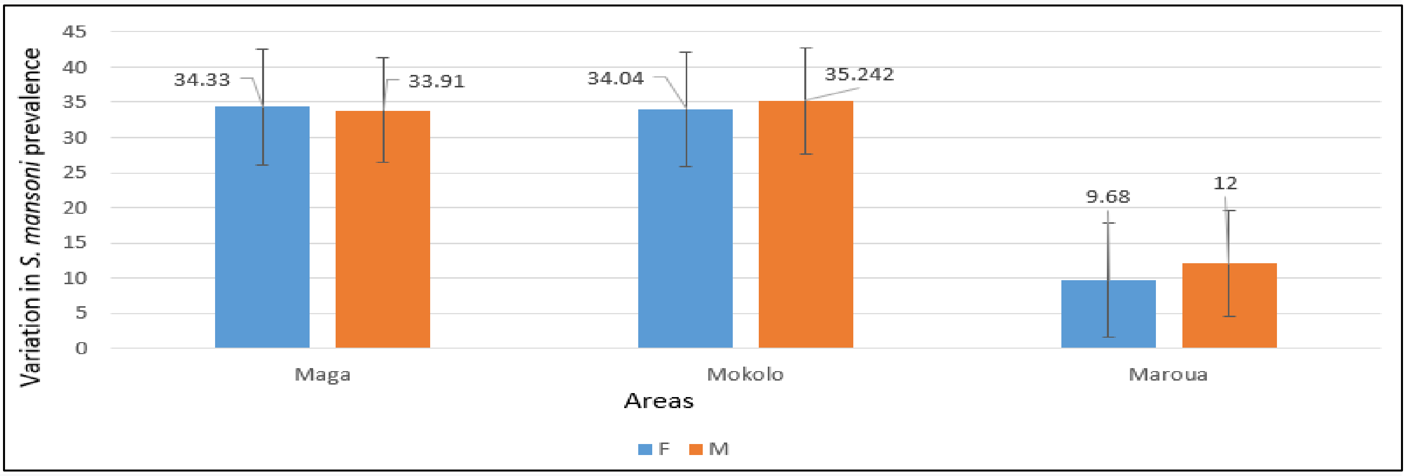

Fig 10 Prevalence of Schistosoma Mansoni according to Sex
Legend: F = Feminine; M = Masculine

This work shows that the prevalence of males is significantly more infested than females (ddl = 5; p = 0.001; alpha = 0.05). It is also noted that among females, the infestation rate is significantly higher in Maga than in Maroua (z = 8.72). Among males, the infestation rate is significantly higher in Mokolo compared to Maroua (z = 8.04).

The fact that *S. masoni* infestation is higher among subjects living at the edges of lakes could be explained by the fact that carrying out household chores or fishing activities in Maga and Mokolo could explain this result.

The recorded results show that the prevalence of *E. histolityca* varies in different regions (Figure 10).

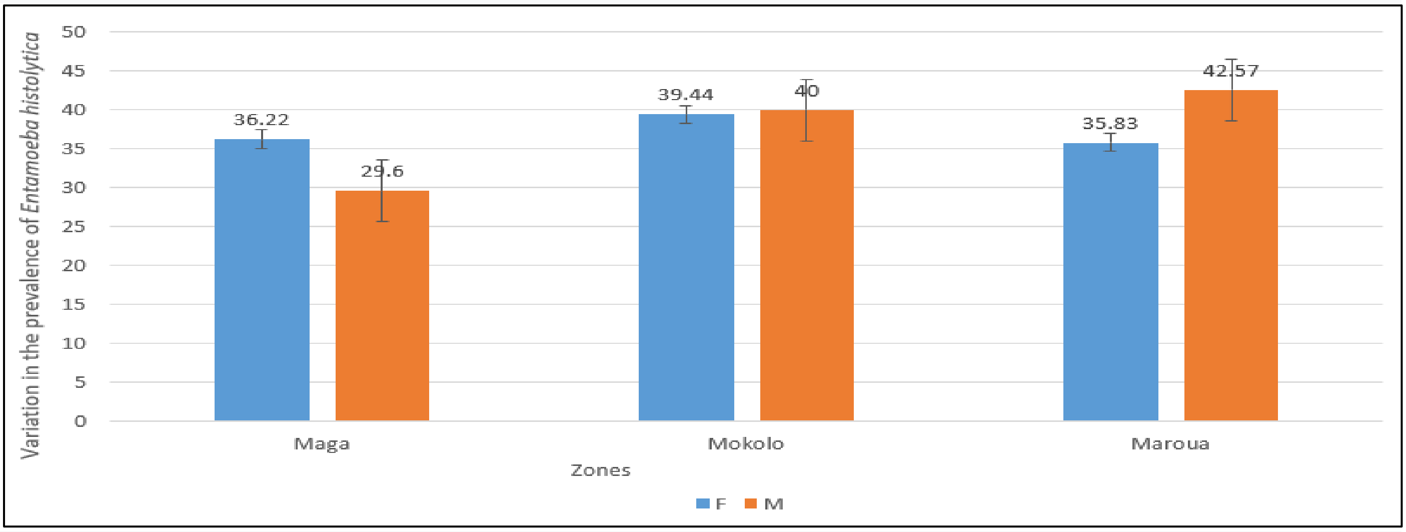

Fig 11 Prevalence of *Entamoeba histolytica* according to Sex
Légende : F= Féminin ; M= Masculin

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jul1403

This figure shows that the prevalence among females is and (ddl=5; p=0.139; alpha=0.05). Among males, the infestation rate is higher in Maroua than in Maga (z=15.06). Also, the prevalence among men is sufficiently higher in Mokolo than in Maroua (z = 3.11). On the other hand, there is no significant difference in the infestation rates between women in these two localities (z = 0.94).

These results are believed to be due to the scarcity of water, which results in a lack of personal hygiene of both sexes. The high number of infestations noted among males in Maroua is due to the consumption of food and fruits offered by street vendors at their places of service.

➢ *Variation of Parasites in Urine*

- *Variation according to the Seasons*

From the results presented, we note that the prevalence of *Schistosoma hematotobium* varies according to the seasons in the different study areas (Figure 11).

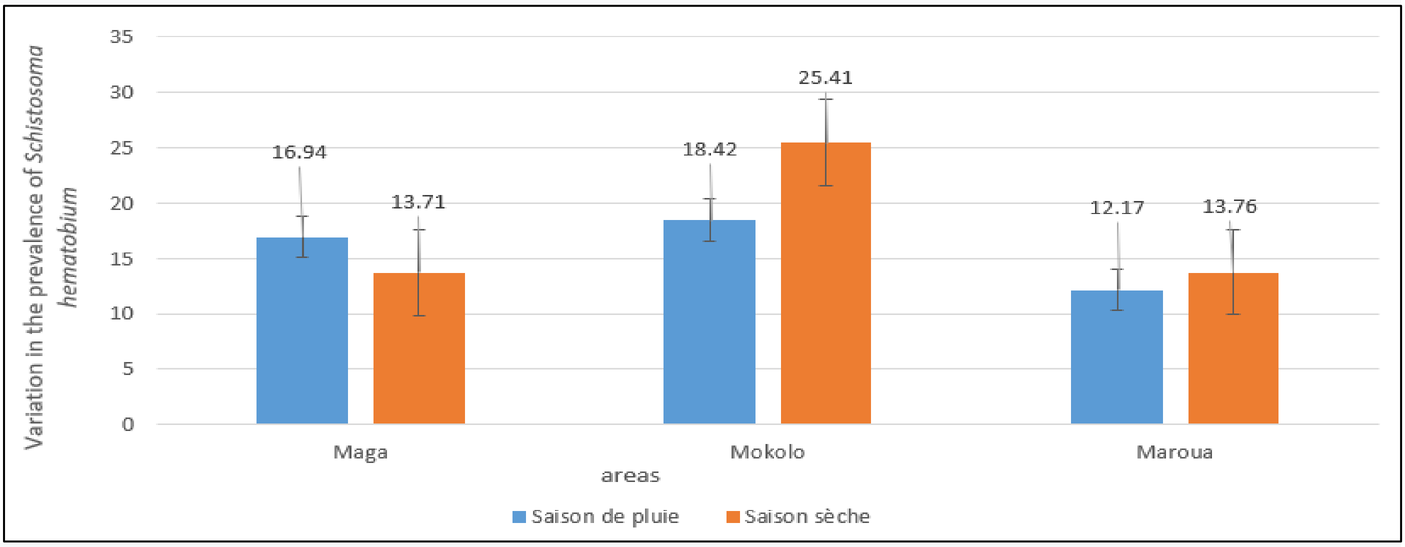

Fig 12 Prevalence of *Schistosoma haematobium* according to Seasons

The infestation rates of *S. haematobium* show no significant difference (ddl= 5; p= 0.018; alpha= 0.05) between the rainy season and the dry season. However, it is also noted that the infestation rates during the rainy season are higher in Mokolo than in Maroua (z = 2.29). Similarly, the infestation rate during the dry season is higher in Mokolo than in Maroua (z=3.28) and in Maga (z = 4.22).

These results are likely due to the constant attendance to contaminated waters throughout the year. They can be explained by the fact that during the dry season, the scarcity of drinking water leads the populations of Maga and Mokolo to drink from the lakes of Maga and Mokolo, while during the rainy season, the lake of Maga overflows its banks and floods nearby areas, thus spreading the mollusks that are vectors for the transmission of the parasite.

- *Variation of Parasites according to Age*

The recorded results show us the variations in the prevalences of *Schistosoma hematobium* vary with age in the Far North of Cameroon (Figure 12).

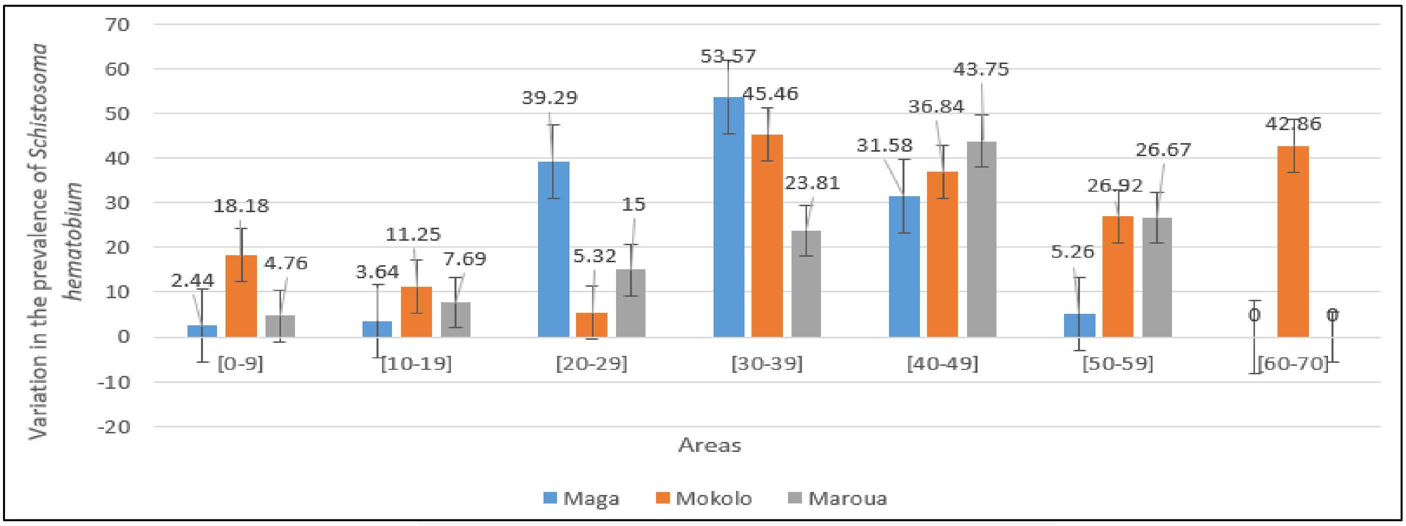

Fig 13 Prevalences of *Schistosoma haematobium* according to Age

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25jul1403

From this figure, we observe a highly significant variation in parasitic prevalences (ddl= 20; p= 0.00001; alpha= 0.05) between different age groups. We also note that among individuals aged 0-9 years, 10-19 years, and 60-70 years, the infestation rate is higher in Mokolo than in Maga (z = 8.58; z = 6.44 and z = 10) and in Maroua (z = 7.14; z = 2.61; z = 10). It is also worth noting that among individuals aged between 20-29 years, the infestation rate is higher in Maga than in Mokolo (z = 8.57) and in Maroua (z = 5.78); similarly, among individuals aged between 30-39 years, the infestation rate is higher in Maga than in Maroua. However, among individuals aged between 40-49 years, the infestation rate is higher in Maroua than in Maga (z = 7.88).

These results can be explained by the fact that during our investigations, children and adolescents had benefited from the deworming campaign.

- *Variation Depending on Sex*

The results show us the prevalence of *Schistosoma hematobium* by sex in Far North Cameroon (figure 13).

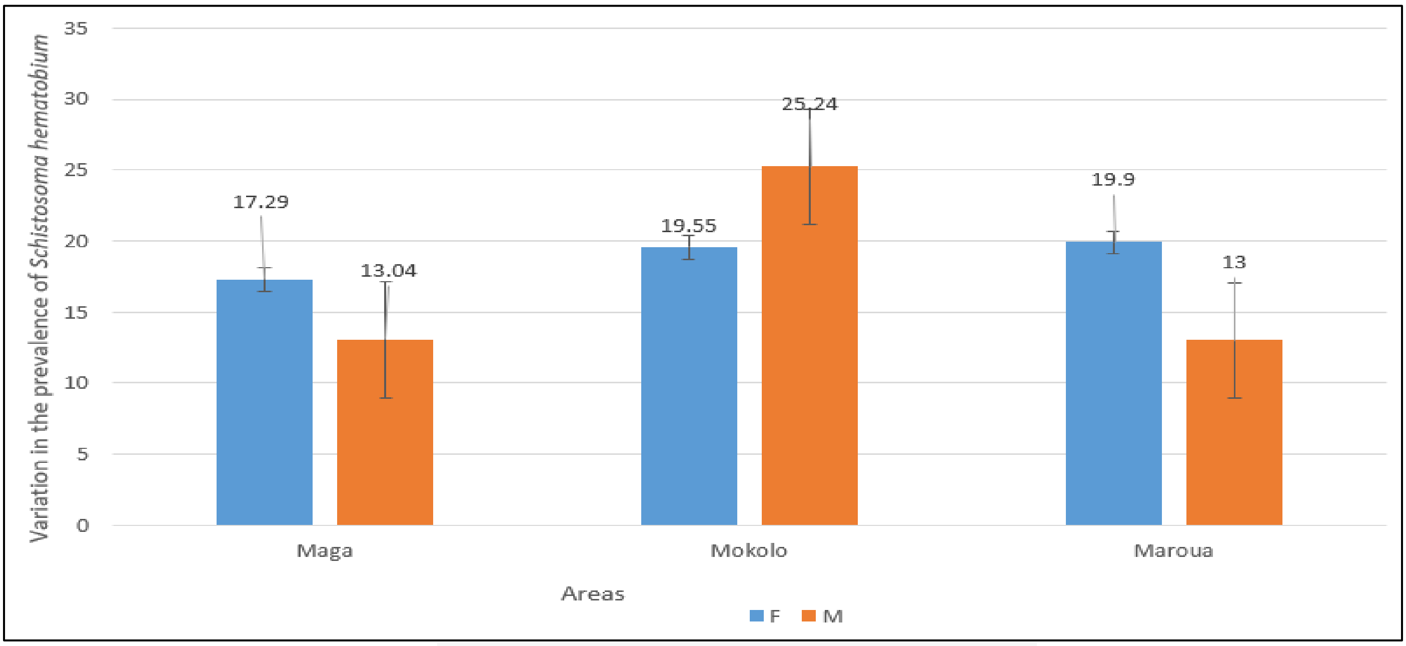

Fig 14 Prevalences of *Schistosoma haematobium* Based on Sex
Legend: F = Feminine; M = Masculine

It appears from this figure that the prevalences among females show no significant difference compared to males (ddl=5; p=0.024; alpha=0.05). However, the infestation rate among males is higher in Mokolo than in Maroua (z=4.44).

These prevalences are lower than the 69.5% obtained by Nkengazong *et al.* (2009) in Barombi-Kotto in the Southwest. The increase observed in the lake environments of Maga and Mokolo would be explained by the fact that these environments are favorable for the development and survival of intermediate hosts responsible for the transmission of the parasite such as Bulinus truncatus. Yelnik *et al.* (1982) mention that the abundant presence of *B. truncatus* in the artificial lake of Maga, which makes it particularly effective in the transmission of schistosomiasis in this area. Shortly after Greer *et al.* (1990); Ratard *et al.* (1990) confirm that *B. globosus* and *B. truncatus* are the main intermediate hosts of *S. haematobium* in the Far North region. On the other hand, Ernould *et al.* (2004) show that in the irrigated areas of Niger, the distribution of the bilharzian risk appears closely linked to the proximity of the habitat to secondary irrigation canals. Through the studies carried out in the Volta basin in Burkina Faso, Parent *et al.*, (1997) then Poda (2007), show that the levels of endemicity of schistosomiasis depending on the level of initial endemicity, the distance between the place of residence and the places of potential transmission and the sociological phenomena that link man and the places of contamination. These parameters provide conditions conducive to human contact with contaminated water ; hydraulic installations constitute a factor in the intensification of *S. haematobium* contamination (Sellin *et al.*, 1986; Poda *et al.*, 2004).

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