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Research Article

Onchocerciasis Prevalence and Transmission Potential of *Simulium* spp. in Three Areas of the Northern Regions of Cameroonl

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ABSTRACT

Background: Onchocerciasis is an infection caused by *Onchocerca volvulus*: A filarial nematode transmitted by *Simulium* spp. More than 99% of infected people live in 30 countries in sub-Saharan Africa, 37 million people are carriers of *Onchocerca volvulus* in Central and East Africa, and 800,000 blinds people are recorded. Villages in northern Cameroon had more than 80% microfilaria index in 1991 with bilateral blindness rates 1.7% to 4.0%.

Methods: Three villages have been selected to study: Lagaye in the district of Touboro, Mandjiri in the department of Vina (Adamawa), and Mayo-Salah in Mayo Rey Department. Concerning the parasitological research, the persons to be examined have been gathered by sex (female and male) and age group. Three age groups were concerned: 5 to 9 years, 10 to 15 years, and beyond 16 years. Using a vaccine style and a razor blade, a 2 mm fragment of skin was removed from the scapula, iliac crest, and calf. The place for removing was cleaned with alcohol (95°C). The skin was placed in a tube containing 2 mL of physiological water (NaCl, 9%) for 24 hours then centrifuged. The pellet was collected for direct examination and stained with the Giemsa, then observed on a binocular microscope. Entomologically, an adult of black flies was captured on human bait and dissected under the entomological microscope. Their physiological age has been determinate. The blackfly was dilacerated to search all the stages of filariae larvae.

Results: Seven (07) out of 165 skin samples were found positive, giving an overall parasite prevalence of 4.24%. According to the distribution of the prevalence by sex, it appears that the male was the most infected (6/165) 3.64%, with (1/165) 0.60% for females. Entomologically, 11,695 black flies were captured; only 4,065 females were dissected (34.75%). Of these females, 2,514 (61.84%) were parous exhibiting structures with semi-clear or clear Malpighi tubes, 1,418 (34.88%) nulliparous presenting opaque Malpighi tubes. As regards parasitological research only 229 (5.63%) blackflies were infected by *Onchocerca volvulus* all confounded forms among which 125 (3.07%) carrying infected stage (L3).

Conclusion: At the end of our investigation, the results revealed that there are still vectors of onchocerciasis and the transmission of this human parasite in the regions is still ongoing.

Keywords: Simulium; Entomological; Onchocerciasis; Transmission; *Onchocerca volvulus*

INTRODUCTION

Onchocerciasis or "river blindness" is a parasitic disease caused by a roundworm, Onchocerca volvulus, a filarial nematode transmitted to humans by the bite of a black fly of the genus *Simulium spp* [1]. Onchocerciasis is a public health problem in Yemen, Oman, Central, and South America, and sub-Saharan Africa [2]. In the north region of Cameroon, Mayo Boki, Mayo Salah, and Mayo Pounko, tributaries the right branch of Benoue River, maintained these endemic foci. The villages located on the roads from Gouna to Tchamba and from Tchamba to Beka had more than 80% of the micro filarial index [3]. The most heavily infected villages in Mayo Rey were located between Tcholliré and Sorombéo and that rates of bilateral blindness were between 1.7% and 4.0%. This same author pointed out that in Mayo Galké the blindness rate in 1983 went

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from 3% to 4.3% and 7.6% of blind people according to Boussinesq [3]. A study carried out between 2008 and 2010 in Touboro recorded 7.7% microfilaria rate [4]. The Koubao and Babidan villages showed 12.9% and 17.1% microfilaria rates respectively. Eye damages as well have been observed in Touboro, Rey-Bouba, and Tcholliré with respective rates of 13.2%; 13.5%, and 5.4%. In the villages of Mamfe, Eyumojok, and Kumba in the South West Region, it was reported that the rate of microfilariae in the nodules was respectively 47%, 36.4%, and 49.7% in children [5]. At the current state of knowledge, there is no reliable scientific data on onchocerciasis in the areas explored, namely Mandjiri, Mayo Salah, and Lagaye. The general aim of the study is an epidemiological investigation on onchocerciasis caused by *Onchocerca volvulus* at the Adamaoua and North regions of Cameroon, because of developing effective control strategies against this scourge. To achieve this aim, the density of vectors namely the *Simulium spp* the presence of Onchocerca volvulus larvae in the digestive system of the black flies and their physiological age were evaluated.

MATERIAL AND METHODS

Study areas

The study sites were located in North and Adamaoua regions previously known being endemic. The village of Mandjiri is a small locality of Wakwa in the division of Vina (Adamaoua region). It is crossed by the river "Vina Sud" and geographically located on a point of latitude 7°32'80"N longitude 13°35'637"E on an altitude of 1065 meters. Lagaye village belongs to Touboro in the Rey Bouba division (North region). It is crossed by the river "Vina Nord" with geographic coordinates of 7°46'60"N latitude, 15°22 '04"E longitude, and of 531 meters altitude. Mayo-Salah is located 5 km away from Gouna in the division of Poli (North region) crossed by the river "Benoué" with geographic coordinates of 8°30'54"N latitude 13°40'33"E longitude and 255 meters altitude. The three villages have a dense hydrographic regimen and abundant fauna of insects flies within which the blackflies.

Ethical approval

All participants for the study received full and detailed information about the study procedures and aims based on their local language. Each participant agreed verbally and consented to participate as a volunteer in the study. All volunteers accepted to participate in the study, including black fly collectors, received Ivermectin treatment before. The study was approved by the community leaders, Research Authorization issued by the University of Ngaoundéré-Cameroon; Ethics authorization issued by the Health District of Vina Adamaoua-Cameroon; Ethics authorization issued by the Regional Delegate of Public Health of North Cameroon.

Data processing

The statistical processing of the data was carried out using SPSS software. Data analysis was done using:

- Descriptive statistics for calculating means and percentages
- Z tests to compare the means observed with a theoretical value
- Student's t-test to compare the observed means with a theoretical value
- Chi-square (χ^2) to compare the proportions observed with a theoretical distribution (Schwartz distribution, 1996)
- Mann-Whitney U test to compare the independent variables
- Pearson relationship coefficient test to assess the degree of relationship between two parameters

The correlation coefficient (r) to measure the intensity and direction of the relationship between two variables.

Prevalence=(Number of people positive on biopsy)/(Total number of people examined in the village) × 100;

Parturity rate=(Number of parous flies)/(Total number of parous+nulliparous flies) × 100;

Infectivity rate=(Number of black flies with (L1L2L3)/(Total number of dissected black flies) × 100;

Infectivity rate=(Number of black flies with L3)/(Total number of dissected black flies) × 100.

Capture on human bait

To capture black flies, the technique was used [6-9]. This technique involves using humans as bait, from 7 a.m. to 7 p.m. sheltered from the wind and sun; the captor with his legs bare to the knees. The blackflies are attracted to the naked parts predominantly legs. They are then captured during their blood meal by sucking them in with the suction nozzle oriented towards the immotile. The places of capture have prospected previously. The capture areas respected the following criteria: the presence of rivers or "mayo", the presence of black flies called in the local language "Moutmout", "Sihon" "Moukkoye", the history of people suffering from manifestations caused by blackflies bites in a local health center, the human habitations in rural areas and places of agricultural fields and animal husbandry. The captures took place at the side of the stream, of the mayos or rivers. The capture points were in the shade, isolated by thick vegetation, located outside the city and its surroundings.

Determination of parasite prevalence

A population of 165 subjects was sampled and formally diagnosed. The sample consists of female and male individuals and divided by age group: 5-9 years old; 10-15 years and 16 years and over. On each of the subjects, skin biopsies were taken at the iliac crest and scapula. Concretely, before the sampling, the site was cleaned with a 95% ethanol solution. Using a sterile vaccine style, a light cut was carried out in such a way that the snip can be easily cut out using a sterile scalpel/razor blade. The collected skin snips were put in a 10 mL tube containing 2 mL of sterile saline solution (NaCl, 9%). An incubation at room temperature for 24 hours to allow microfilariae release. The solution was then observed under a photonic microscope and *Onchocerca volvulus* microfilariae identified according to their morphologic characteristics *Onchocerca volvulus* has no sheath, possess a slender tail, curved, without pits. The cephalic space is long and wide. She measures 310 µm (280-320) µm.

Dissection of blackfly ovaries

The dissection technique was described by Lewis and could be performed under an entomological microscope [10,11]. It is used to identify nulliparous flies (having never laid eggs) and parous

flies (having carried out at least one gonotrophic cycles) based on the visual characteristics of their ovaries and Malpighi tubes. One blackfly settled one drop of water of saline solution on a glass slide. Under an entomological microscope, the blackfly was dissected and scrutinized. The ovaries and Malpighi tubes were identified and examined. The physiological age of the blackfly was determined by examining the appearance and consistency of the ovaries and the transparency or the opacity of the Malpighi tubes under incident light from the microscope. The strength and flexibility of the ovary are variable. The nulliparous fly's ovary does not stretch very much before breaking suddenly while the parous one stretches over its entire length and tear slowly. Besides, Malpighi tubes present variable behavior to the light; they can be opaque or semi-opaque and semi-clear or clear for nulliparous and parous flies respectively.

RESULTS AND DISCUSSION

The density of black flies

Table 1 and Figure 1 presents the biting rate (b/d/m) for 8 months (June to January) in the three areas for three years. To determine the monthly biting rates (MBR) we used the following previously published procedures the formula: MBR=(Number of flies caught × Days in the month)/Number of catching days [9].

Table 1: Variation in the intensity of biting received per man by the village.

Months	Lagaye	Mandjiri	Mayo Salah
	B/M/D	B/M/D	B/M/D
June	5	7	8
July	4	8	17
August	8	35	38
September	8	39	17
October	8	46	31
November	7	29	13
December	7	29	3
January	7	7	1
Cumulated Density	54	200	128

M: Man; D: Day; B: Bite; M: B/M/D: Bite Per Man Per Day

In each village, black flies were collected for four days a month by two trained volunteers from the local communities who received regular quarterly Ivermectin treatments. It can be noticed that the aggression activity of the blackflies is variable according to the area; the higher the biting density is, the stronger, the vector aggressively is. Thus, the highest aggressiveness was registered in Mandjiri with a cumulative biting density of 200 b/m/d (200 bites × 30/4/man/month (3000 b/man/month) and the lowest in Lagaye (54 bites/man/day). The Mayo Salah village presented a moderate aggressiveness of the vector compared to the other areas with a cumulative density of 127 b/m/d. These densities are quite high compared to those obtained by Wanji et al., 313.5, and 285 infective larvae/man/month for Babong and Kajifu respectively [5]. Eyong et al. noted a theoretical density of 436 b/m/d in the Bolo site with a maximum density in the rainy season: 800 b/m/d and a minimum of 100 b/m/d [12]. Most of the lowest densities were recorded in Lagaye in June, and July in the order of 4 b/m/d-5 b/m/d and the highest in Mandjiri (46 b/m/d). The lowest cumulative density 54 b/m/d is reached in the village Lagaye and the highest density 200 b/m/d was recorded in the village Mandjiri. The variation of the density might be due to the presence of potential human (blood resource) during the rainy season characterized by the increase of agricultural activities. Also, it could be assuming that blackflies only bite during the day and their activity ceases when it rains or when the temperature is too high [13]. We can admit that these nuisances reduce agricultural and fishery activities. Furthermore, Le Berre in 1966 had noticed that the variation in the quantity of food in the stream of water influences the dynamics of the blackfly's population. A weak water current (0.30 m/s to 0.40 m/s) favored the installation of the pre-imaginary stages. A strong one increases the installation of secondary lodges and the cessation of rain eliminates them [14].

In natural conditions, the transmission of onchocerciasis depends on the subject who was infected by the larvae. In the Marquesas archipelago in French Polynesia, Sechan and Loncke noted that black flies were a considerable nuisance because of their painful stings [15]. These authors calculated the cumulative aggressiveness density which was 12,500 b/m/d by the river in an inhabited area and 14,500 b/m/d in a remote inhabited area. The bites inflicted on humans cause intense pruritus and are a serious obstacle to the development of agriculture. Entomological indices based on daily aggressiveness rates show that the vectors of onchocerciasis are present and are abundant in the study areas. This abundance impedes agricultural and fishery activities, which results in lower annual productivity. The variations in the daily rate of activity of blackflies are closely linked to variations of temperature, humidity, rainfall, and light [13,14,16]. However, it should not be overlooked that the temperature above 27°C forces the blackflies to confine themselves thereby lowering the abundance [14]. Also, the wind is a factor influencing the activity of these vectors but it could on the contrary favour human activities.

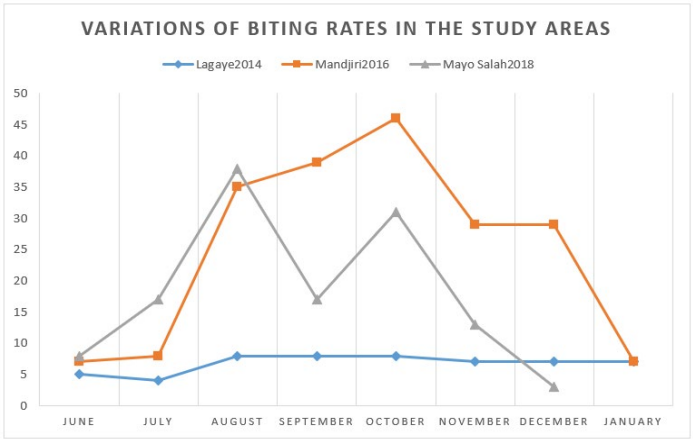

Figure 1: Variation in the intensity of biting received per man by the village.

Parasite prevalence

The 8 months of data concerning the biopsies taken from the sampled subjects are presented in Table 2. Out of 165 individuals, 07 subjects were positive (presence of microfilariae), giving an overall parasite prevalence of 4.24%. According to these data, the most parasitized area is Mayo-Salah (2.42%) followed by Lagaye (1.21%) and the least one is Mandjiri (0.61%). Male subjects are much more infected than female ones. The highest male subject's prevalence value was recorded in Mayo-Salah and Mandjiri

Table 2: Parasite prevalence by age, sex in the study areas.

Age ranges (years)	Lagaye		Mandjiri		Mayo-Salah		Person tested		Positive tested		Negative tested
	M	F	M	F	M	F	M	F	M	F	
(5-9)	0	4	4	4	6	6	10	14	0	1	23
(10-15)	2	0	7	4	5	9	11	13	0	1	23
(16-80)	23	21	9	23	14	25	45	72	1	4	112
Positive	1	1	0	1	0	4					
Negative	24	24	20	29	25	36					
Total	25	25	20	30	25	40	66	99			

Variables	Ages (years)			Sex		Villagers		
	(5-9)	(10-15)	(16-80)	M	F	Lagaye	Mandjiri	Mayo-Salah
P(%)	0.61%	0.61%	3.02%	1.21%	3.03%	1.21%	0.61%	2.42%

P: Prevalence; M: Male; F: Female

Table 3: Dermal and ocular manifestations in a few subjects from the 165 sampled.

Variable	Examined	Nodules	Hanging groin	Keratitis	Blindness	Scabies filarial	Pruritus	Leopard skin
Children	48	0	0	0	0	5	10	0
Adults	117	5	4	2	3	2	6	1
Prevalence		4.27%	3.41%	1.70%	0.80%	4.24%	9.69%	0.85%

NB: the blindness rate is calculated on the census population which is 374 adults and not on the population examined.

Table 4: Overall data on the transmission of onchocerciasis in the area (Adamawa and North).

Months	Blackflies caught	Blackflies dissected	Parous	Nulliparous	Parasitized
June	598	578	328	250	15
July	896	574	288	286	32
August	2514	551	234	217	28
September	1962	505	351	154	26
Rain Ss	5970	2208	1201	907	101
October	2672	547	415	132	45
November	1532	627	430	197	38
December	1214	417	277	143	33
January	307	307	271	37	27
Dry Ss	5725	1857	1313	511	128

Rain Ss: Rainy Season; Dry Ss: Dry Season

(3.03%) and, the highest female subject's one in Lagaye (1.21%). Furthermore, prevalence variation fluctuated concerning age range. The aging seems to be a favoring factor to the infection; the older are the subjects the higher is the microfilariae prevalence. Thus, the prevalence is high in the age range of 16 to 80 (3.02%) compared to the other age ranges (0.61%). This phenomenon can be explained by the fact that individuals in the 16-80 age group are the most active in various occupations such as agriculture, fishing, and gold panning compared to the younger ones.

The results of physical examinations for signs of onchocerciasis are shown in Table 3. A total of 165 people was examined, including 48 children and 117 adults.

Among the manifestations observed are nodules (4.27%), hanging groin (3.41%), keratitis (1.7%), blindness (0.8%) and leopard skin (0.85%) in adults, filarial scabies (4.24%), and pruritus (9.69%) in children and adults. Paris and Pokam conducted a study in the Far North of Cameroon in Koza and they recorded a prevalence of 1.90% of blindness and classified Koza in the hypoendemic zone [17]. In our context, blindness has been evaluated at 0.8%. Although it is not a public health problem (according to the WHO, for a blindness index <2%, the risk of onchocerciasis is insignificant), it still requires special attention from the public authorities. In the absence of vector control and treatment of onchocerciasis parasite reservoirs, there will be a risk of recrudescence. The characteristics of onchocerciasis vary with age and sex. These observations are in agreement with those made in Burundi by Newell, Ndimuruvugo, and Nimpa about the endemicity and clinical manifestations of onchocerciasis in the provinces of Cibitoke and Bubanza [18]. These authors revealed that complaints and symptoms were more frequent with significant differences in positive subjects, in both female and male subjects. They recorded skin lesions (29.9%) in men against (23.6%) in women, 9.4% of nodules in men against 4.7% in women, and 4.4% of cysts in men against 0.6% in women, 2.4% of leopard skin in men. As for pruritus, 34.6% of subjects complained, 26.7% presented skin lesions, 7.1% had palpable subcutaneous nodules and 2.5% had swollen inguinal nodes. A study by Baro Sié in Banyo and Bankim in Cameroon recorded the

prevalence of nodules of 12.3%, 25.3% respectively [19]. According to the classification of "African Program for Onchocerciasis Control" (APOC), the district of Banyo was hypoendemic, Bankim was mesoendemic. An area where the prevalence of nodules is less than 20% do not pose a public health problem. A study conducted in the Bioko Islands (Ubangui basin in the Central Africa Republic) by Boussinesq recorded an overall rate of 0.8% blindness for 13 villages in endemic areas [3]. Our results corroborate those of Boussinesq, our study area is in a hypoendemic situation. However, if our work had extended to several villages, the prevalence rate might be higher than what was recorded in our findings. According to the WHO, for a prevalence of blindness between 2% and 3.49%; the endemicity level is mesoendemic. In children, the pruritus is less but harmful, causing the breakdown of activities. The chronic manifestations observed in adults is the manifestation of an accumulation of parasites of *Onchocerca volvulus* under the skin [3]. According to Philippon, in the savannah the chronic manifestations are severe because the antibody level is low, black flies do not bite all year round in the forest zone where men have a high antibody because of repeated and permanent aggressions [6].

Simulean wildlife

In order to have a global overview of the progress of *Onchocerca volvulus* onchocerciasis in the study area, the data have been grouped in a single (Table 4). Table 4 summarizes the dynamics of onchocerciasis transmission from Mandjiri village in the division of Vina-Adamaoua, Mayo-Salah village in the District of Poli via Lagaye in the District of Touboro, both in the Mayo Rey division.

It appears that 11,695 blackflies were caught overall with a higher achievement during the rainy season (5,970 blackflies) than in the dry season (5,725 blackflies). The number of Simulium flies was found higher ($p \leq 0.05$) in rainy season than in dry one ($Z=178.93$; $DF=3$; $alfa=0.05$). The Mandjiri village presented a higher density with 6230 black flies (53.27%); followed by Mayo Salah with 3,944 black flies (33.72%) and Lagaye where the lowest ($p \leq 0.05$) number of black flies (1521) were captured (13.00%). From the captured flies, 4065 were dissected (34.75%) distributed as follows: 2208 in the rainy season (54.32%) and 1857 (45.68%) in the dry season.

Following the examination of Malpighi tubes, 2514 blackflies were parous distributed as follows: 1201 (47.77%) in the rainy season and 1313 (52.22%) in the dry one. There was significantly ($p \leq 0.05$) much more parous flies in the dry season compared to the rainy one. The parturity rate arisen to 54.32% (2208/4065) during the rainy season against 45.68% in the dry season with an average global parturity of 61.84% but comparing the two seasons, no significant difference was noticed ($p \leq 0.05$). From the captured black flies 229 Onchocerca volvulus (9.11%) infected flies were recorded. As few as 101 parasitic blackflies (4.02%) were captured in the rainy season and significantly ($p \leq 0.05$) more as 128 (5.01%) were collected in the dry season. Eyong et al. conducted a similar study at two sites in Kahn and Bolo, in the North West Cameroon Regional [12]. They found at Bolo a parturity 66.5% in March and January of 80.7%, the period which corresponds to the dry season. Eyong et al. conducted a study in Boali in the Central Africa Republic, on the transmission of onchocerciasis [20]. Parturity was associated with an infection of 16.3% of blackfly carrying parasites. The average parturition rate throughout the year was 61.6%, with monthly variations from 43.5% in October 2000 (end of the rainy season) to 83.3% in March 2001 (end of the season) which is dry season). In the site of Djinglya in the department of Mayo-Tsanaga in Far North Cameroun, Paris and Pokam carried out work on onchocerciasis and captured 69 black flies on human bait [16]. These authors recorded 42% of blackfly flies, of which 51% carried the larvae of *Onchocerca volvulus* Yapi et al. conducted a study to Bouafle in Ivory Coast and recorded a parturition rate of 64.44% which is slightly higher than the 61.84% obtained in our area [21].

As for nulliparous blackflies, they have not been the subject of an important study because of their non-infecting character. Nonetheless, 1418 (34.88%) of the nulliparous black flies were recorded.

Variation of seasonal entomological index

The presence of larvae in flies' digestive tract was observed in each of the investigated areas with a maximum density value of 8.48%, a minimum of 1.52%. It appears from Table 5 that the black flies parasitized by larvae of the 3rd stage at Lagaye varied between 1.52% and 4.69% with a mean of 3.10%. The Mandjiri village recorded a variation in infection of 4.86% with a mean of 3.33% finally a variation between 2.89 and 3.67 was recorded in Mayo-Salah with a mean of 3.88%. Dry season recorded the highest infection rates in each village: 4.69% in Lagaye; 4.89% in Mandjiri; and 3.67% in Mayo-Salah. These observations were studied by Philippon in 1978. He noted that the subject's micro-filarial load is an essential factor which influences the average quantity of microfilariae ingested by a population of *Simulium spp* In addition to this factor, temperature, humidity, and luminosity are likely to play a role in the concentrations of microfilaria *Onchocerca volvulus* in the skin. Microfilaricide medicine destroys only the microfilariae, which disappears from the dermis, then the initial microfilaria load gradually builds up during the 10 to 12 months following the treatment that Philippon observed. Regarding the framework of this study, a thorough investigation did not take place on the use of Ivermectin against filariasis in Cameroon. Observations made in 2014, 2016, and 2018 show the parasitic loads are high in the dry season. The dry season was a factor favoring larval metamorphosis. Larval development depends on temperature: it is shorter when the temperature is high. Entomological indices by season and by village have been recorded in Table 5.

Physiological age

The parturity rate of each focus of the study area during the entire study time is presented in Table 6. It can be noticed that the monthly parturity rate fluctuates between 42.66% in June (Mandjiri) and 89.65% in January (Mayo Salah). In detail, in Lagaye the maximum parturity rate was registered in January (84.46%) and the lowest rate in November (62.21%).

A mean parturity of 1.111% was observed. The Mayo Salah village recorded a monthly parturity rate varying between 45.36% and 89.65% with a peak in January 63.35% noted. The Mandjiri village recorded a monthly between 42.66% and 83% with a peak in December with a mean parturity of 60.87% noted. Seasonal variations have been observed. Thus, it was noted that the village of Lagaye in the rainy season, a parturity of 76.50% was recorded and 74.74% in the dry season i.e. a mean was 75.62% for the two seasons. Mandjiri village recorded 55.69% in the rainy season and71.01% in

Table 5: Data concerning entomological variables by village (Mayo-Salah Lagaye, Mandjiri).

Variable	Lagaye		Mandjiri		Mayo-Salah	
	Rs	Ds	Rs	Ds	Rs	Ds
bc	739	782	2761	3469	2470	1474
bd	624	499	742	867	842	491
bp	405	360	405	612	391	341
bnp	119	142	337	255	451	114
Pbnp	23.49	26.9	41.98	28.97	53.41	20.68
bpzed	30	40	27	49	44	39
b(L3)	16	22	12	31	24	20
PbL	2.75	8.48	3.69	7.38	5.26	7.01
Pb L3	1.52	4.69	1.74	4.86	2.89	3.67
Pruty	76.5	74.74	55.69	71.01	46.58	79.93

P: Percentage; bc: Black Flies Captured; bd: Dissected Blackflies; bp: Blackflies Parous; bnp: Blackflies Nulliparous; bL or infectivity: Black Flies Parasitized by Larvae L1 L2 L3; b (L3) or infectivity: FL3 Larvae; bL: Parasitized Females; L3: 3rd Infecting Larva; L2: 2nd Stage Larva; L1: 1st Instar Larva; To C: Temperature in Degrees Celsius; pruty: Parturity; Rs: Rainy Season; Ds: Dry Season

Table 6: Data on monthly parturition rates by the village.

Months	Lagaye	Mandjiri	Mayo Salah
	P pruty	P pruty	P pruty
June	81	42.66	45.36
July	65.62	44.95	46.49
August	77.19	50.74	45.59
September	82.19	47.97	85.34
October	81.02	75.45	73.61
November	62.21	81.39	61.66
December	67.25	82.97	59.13
January	84.46	0	89.65

Ppruty: Percentage of De Parturity

the dry season i.e 63.35% mean was noted finally. The Mayo-Salah village was marked by a mean of 46.58% in the rainy season and 79.93% in the dry season with a mean of 63.25%. Black flies have been biting more in the morning and midday [22]. Furthermore, black flies react differently to temperature variations depending on their age. This is how older blackflies, therefore parous, are more active than nulliparous when the temperatures increase. The black flies manifest their greatest abundance as soon as the temperature falls down. The different variations in parturity in the three sites might come from the fluctuation of temperature. The observations made by Yapi et al. in Bouaflé in the Ivory Coast who shown that for an average parturity rate of 64.44%, the blackflies are old in the study area [20]. It was noted that the Lagaye village recorded the highest parturity rate resulting in increased longevity of the black flies. On contrary, in Mandjiri village in the Adamawa Region, the mean parturity was been 53.26% which characterized the forest species, this parturity oscillated between 20% and 50% for the forest species so the age of the species savannah was been around 60% [22]. This study conducted by Philippon was similar to our findings in Lagaye and Mandjiri which the parturity was around 60%. Nevertheless, it was observed a parturity of 46.58% in the rainy season in the village of Mayo-Salah. This can be explained by the presence of the larval lodging not far from the places of capture and doing emerge abundant young nulliparous blackflies. The conditions of temperature and humidity in dry season appear suitable for black flies' copulation [22]. In savannah areas, black flies tend to concentrate at the edge of rivers. Traoré et al. conducted a study in Tai, Ivory Coast, in which 41.3% parturity rates were recorded [8]. The proportion that we have recorded are above except in Mayo-Salah with 46.58% has been recorded. The parturity rate between 20% and 50% according to Philippon characterizes forest species. The captures made in the afternoon are favorable for the harvest of nulliparous [22]. Quillevere et al. conducted studies on the entomological index in seven villages in the Ivory Coast. These authors recorded a rate of between 11% and 58.4% with a global of 45% [7]. The lowest parturity rates were recorded in Mandjiri in June which was 42% with a high level of 83% in December. Eyong et al. noticed a rate of 61.6% with a monthly variation between 43.5% in the rainy season and 83.3% in the dry season [20]. Besides, Simaro et al. conducted a similar study in Ivory Coast in the localities of Soubré, Bouaflé, and Touba and recorded the rates of 28%, 69.23%, and 77.66% respectively [23].

Blackfly infection with *Onchocerca volvulus*

Table 7 summarizes the infectiveness of blackflies in each village. The infectivity rates in Lagaye varied between 6.3% during the flood, and 2.32% at the start of the dry season with a peak in October. That of the Mandjiri village is between 6% during the rainy season and 0.87% at the start of the rain peaks in September and October.

Infectivity rates in Mayo-Salah ranged from 5% during the flood period to 1.40% at the start of the rainy season. The Mayo-Salah village recorded a monthly infectivity rate which ranged between 0.55% and 1.40% with a peak in November. The global infection in Lagaye was 24.88% with mean infectivity of 3.11%. The in Mandjiri village is 26.45% with a mean of 3.30%. Finally, in the Mayo-Salah village was 22.61% with an average of 2.82%. The village of Lagaye had the highest mean infectivity rate. Traoré et al. conducted a study in Taï Ivory Coast, at the end, 4% of infectivity rates were recorded [8]. Philippon had recorded 3% of the infected blackflies [22]. These values are similar to our records obtained in Mandjiri. Quillevere et al. conducted studies on entomological indices in seven villages in Ivory Coast and noted an infectiveness rate between 6.1% and 25% and with a mean between 10.9% and

15.3%, which is higher those in our findings [7]. Data on monthly infectivity rates (parasite L1, L2, L3) in the villages Lagaye, Mayo-Salah, and Mandjiri are summarized in Table 7.

Table 7: Monthly infectivity rate by the village.

Months	Lagaye		Mandjiri		Mayo Salah	
	InR		InR		InR	
June	0		1.46		1.77	
July	0		0.87		2.29	
August	3.5		2.07		3.48	
September	2.61		2.59		4.04	
October	6.3		5.55		3.18	
November	2.32		4.16		4.65	
December	5.3		4.33		3.2	
January	4.85		5.42		0	
Seasons	Rs	Ds	Rs	Ds	Rs	Ds
Pruté	76.5	74.74	55.69	71.01	46.58	79.93

CONCLUSION

Parasitological, the overall prevalence appears to be low in the study area. This prevalence is higher in the 16-80 age group. Given the large number of black flies captured on human subjects, it appears that these black flies have a low vector capacity compared to the parasite prevalence. The majority of black flies are sparse but few are infected. Aggressive density is higher in the rainy season; however, the transmission of onchocerciasis is higher in the dry season. This transmission is discontinued during the year and results in time intervals. The risk of an onchocerciasis resurgence is likely given the behavior of the inhabitants of the study sites who are unaware that black flies are the vector agents of *Onchocerca volvulus* of onchocerciasis.

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