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Full Length Research Paper

Epilepsy Risks and Porcine Farming in North West Cameroon: A Comprehensive Analysis

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This study posits that socioeconomic factors determine the patterns of epilepsy. The transmission of cysticerci between pig and man is facilitated by traditional pig rearing, slaughtering, and the poor detection of *Taenia solium* in slaughter pigs. Neurocysticercosis, resulting from *T. solium* is often associated with focal epilepsy. To ascertain this relationship, a co-relational design was applied to compare epilepsy prevalence with human activities that may predispose people to the risks of the disease. Information on epilepsy and *T. solium* was sourced from survey by questionnaire. Hospitals and non-governmental organisations (NGOs) also provided information. The lack of coherent data on epilepsy however lessened the desired rigour in the test of the association of *T. solium* and epilepsy. Whereas porcine farming and epilepsy were reported from the entire region, Mezan and Batibo dominated both. The obtained Kendall's tau of -0.881 indicated a strong negative correlation between epilepsy and pork consumption in the areas surveyed. Notwithstanding, the disagreement among researchers on the association between neurocysticercosis and epilepsy, agreement is strong on the association of neorocysticercosis porcine farming areas. Thus, the strength of this study resides in the attempt to pattern porcine farming and epilepsy geographically. Such surveys can provide clues to disease control and the fight against *T. solium*.

Key words: Epilepsy, porcine farming, *Taenia solium*, neurocysticercosis, Batibo, Cameroon.

INTRODUCTION

Epilepsy is estimated to affect over 43 million people worldwide, 12.4 million of whom are in South East Asia, 9.8 million in the Western Pacific, 9.4 million in the Americas, 3.4 million in Eastern Mediterranean, 3.3 million in Africa and 5.1 million in Europe (WHO, 2005). In Cameroon, it represents 15.78% of all neurological consultations in adults and 1.85% in paediatric consultations (MINSANTE, 2009). The Cameroon Epilepsy Foundation estimates that over 35000 epilepsy patients are in the north-west of the country.

Epilepsy is one of the oldest but most misunderstood diseases in the tropics. It has been defined as a

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dysfunction of the brain cells that lead to repeated seizures, the seizures representing the periods of loss of consciousness and excessive muscular activity in the patient caused by high brain discharges (Dekker, 2002). Until recently, knowledge of the aetiology of epilepsy was inexistent leading to mere speculations and beliefs about its causes. Such knowledge has improved today though not conclusively (Zoli et al., 2003; Elliot et al., 2013; Thomas et al., 2016). In medieval Europe, epileptics were thought to be possessed and often ostracized and sometimes even killed (Onwuekwe, 2007). In most of Africa, the misconceptions around the disease are still very strong as many people believe that it is caused by the supernatural influences of evil spirits and witchcraft and that it is contagious (Onwuekwe, 2007; Dung et al., 2008; Ntaimah, 2008; Aall, 2004). Epilepsy is probably the most common chronic neurological disorder in the world (Paul et al., 2012; Onwuekwe, 2007). The prevalence of the ailment varies with age group. In Africa, the prevalence is 11.5 patients per 1000 in the 20 to 29 age group; 8.2 patients per 1000 in the 40 to 49 age group and 3.1 patients per 1000 in those above 60 years (Paul, 2012).

Despite its global incidence, epilepsy is more burden-some on African families as nearly 9 of every 10 patients on the continent may not receive adequate medical treatment (Boer et al., 2007). This situation cannot be understood only in economic and financial terms, but also within the framework of the belief system that stigmatizes epileptics causing people to fear, neglect, despise and refuse them help (Njamnshi et al., 2009a, b).

Knowledge on the aetiology of epilepsy has grown tremendously in the past 100 years. It is now known to result from brain dysfunction which may be caused by numerous factors: asphyxia, head injury and meningitis, in symptomatic epilepsy and idiopathic epilepsy in the case of genetic dispositions.

Social and economic factors are crucial in determining the incidence and prevalence of most diseases including epilepsy because they affect patients' accessibility to relevant health care resources. The social practices, income poverty, poor sanitation and ill-equipped health care systems of the developing countries limit treatment possibilities causing the incidence of the disease to vary from one place to another, thereby lending credence to the assertion that local circumstances may be influential in its epidemiology. This view was first articulated by Dr Guillermo Casis Sacre, while practicing medicine in the Mexican states of Chiapas and Oaxaca (Aall, 2004) and later by Dekker (2002), Onwuekwe (2007), De Boer (2008).

Based on this premise, this study posits that even in genetically predisposed populations, environmental, social and economic factors are likely to play a significant role in the overall pattern of epilepsy infections in a locality. The study is based on the facts that if *Falciparum* malaria, *Taenia solium* larvae*, Toxocara canis* and *Onchocerciasis vulvulus,* agents found to be associated with epileptic people have clear ecologies, the geographical aetiologies of epilepsy can be explained in terms of the habitat or geogens of their vectors. Such studies are rare and their importance can be seen in the attempt to pattern epilepsy geographically, thereby producing the type of knowledge health care planners and administrators require to strengthen specialized health care delivery systems vis-à-vis health promotion and protection programmes in high risk epilepsy zones.

Ecology of epilepsy

Like many infectious diseases, the burdens of epilepsy are heavier in the developing than developed countries (Kaiser et al., 1996; De Boer et al., 2008; Zoli et al., 2003). Epilepsy is a disease which affects people at all ages although it is more pronounced in the populations under 20 and above 60 years. Even though many seizures occur without clearly identifiable causes (idiopathic), brain dysfunction is now established as a primary cause of seizures. Brain dysfunction may result from a variety of causes including asphyxia, head injury and meningitis. It may also result from the development of cysts in brain tissue.

In the developing countries, neurocysticercosis is a common cause of seizures. Neurocysticercosis is caused by the young form of the pork tape worm. In its larval stage, the pork tapeworm infects the nervous system and penetrates brain tissue causing neurocysticercosis or larval cysts, a disease which has been found to be one of the main causes of focal epileptic seizures (Garcia et al., 2003; Zoli et al., 2003). Another parasite like the *O. volvulus*, a nematode that causes onchocerciasis has also been reported to be a cause of epilepsy. Since environmental factors determine the ranges of tolerance of specific parasites, vector-borne diseases can be patterned geographically. In this perspective, the ecological pattern of focal epilepsy, most often associated with cysticercosis can easily be established. Such was the approach that inspired the hypothesis that *O. volvulus*, transmitted by S*imulium damnosum* (the blackfly) may cause epileptic seizures when it migrates to the brain. It was first put forward in the 1930s by Mexican physicians practicing in the States of Chiapas and Oaxaca (Aall, 2004). Although, Druet-Cabanac et al. (1999) argue that any cause and effect relationship between onchocerciasis and epilepsy are not due to the direct result of microfilariae penetrating healthy blood vessels and migrating into the brain, the close geographical association of the genus *Simulium* (blackfly) and onchocerciasis indicates a causal link which must be explored in other pathological mechanisms (Aall, 2004). Other agents often associated with the occurrence of seizures are *Plasmodium falciparum* and the zoonotic *Toxocara* hosted by dogs and cats with the soil being a

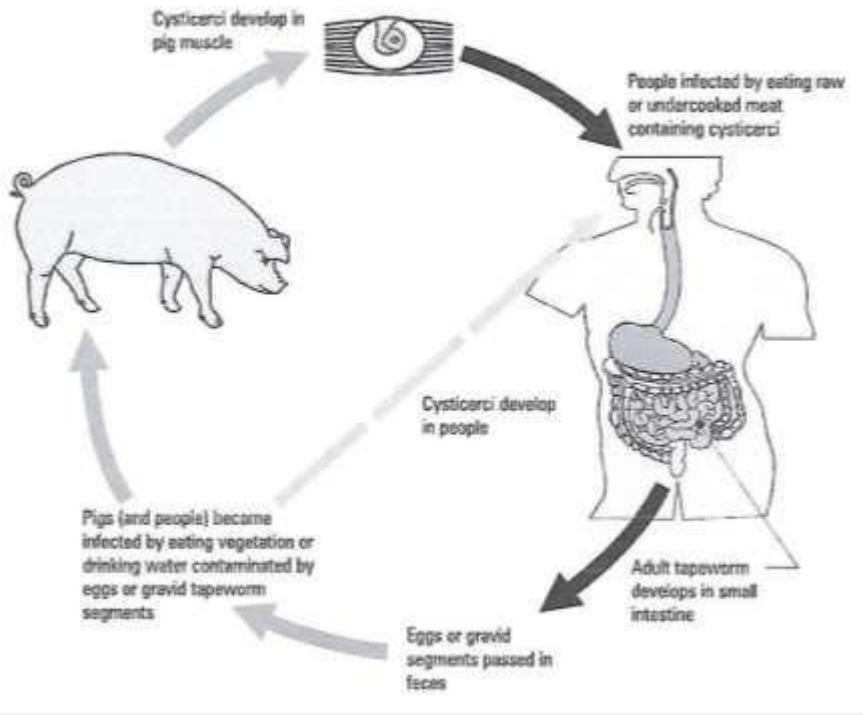

Figure 1. The Life cycle of *T. solium* (Kennedy, 2005; Tapeworms (*Cysticercosis*) in Swine; AGRI-FACTS; Practical Information for Alberta's Agriculture Industry, February 2005).

major reservoir. It infects man when he eats the embryonated eggs of *Toxocara*.

Taenia solium and epilepsy

In the life cycle of *T. solium*, man is the primary host. When man is infected by cysticerci after eating infected pork or through the fecal-oral contamination, he may pass the eggs or gravid proglottids in his feces, thereby transferring the parasite from the intestines to the environment. The eggs have the capacity to remain potent for many months and continue their lifecycle when foraging pigs pick them up in their food. Man may also get infected from this stage by eating vegetation or drinking water contaminated by cysticerci eggs. In the pig, the eggs or gravid proglottids migrate to the intestine as oncospheres breaking through the pig's intestinal walls into its circulatory system eventually anchoring in its muscles as cysticerci, the infective form of *T. solium*. The cycle is repeated when the infected pig's meat is injested by man. The circulation of cysticerci in humans may eventually reach the brain where it forms a cyst (Figure 1).

In disease ecological terms, neurocysticercosis fits within a three or four factor disease complex depending on the locality of infection. Man (primary host) in which the *T. solium* produces clinical symptoms interacts with cysticerci (agent) when he eats infected pork/infected vegetables or drinks infected water. The pig (secondary host) does not exhibit significant clinical symptoms. When people defecate in the nearby bushes where roaming pigs forage and around gardens where runoff may wash the feces onto vegetables gardens and streams, the local environment is turned into a cysticercosis reservoir. Where *T. solium* is endemic, cysticercosis can be described as a four-factor complex involving the primary host, agent, secondary host reservoir, otherwise, it is a three-factor complex if its outbreak is epidemic.

MATERIALS AND METHODS

Spatial context

The study is carried out in Batibo Health district, one of the nineteen health districts of the North-West of Cameroon. It is contiguous with the Batibo sub-division, in Momo division (Figure 2). Its headquarters which lie on the trans-African highway, southwest of the regional city of Bamenda also bears the name Batibo. The Cameroon General Population and Housing Census of 2005 put its population at 44619 with 10350 being urban. Though its climate is tropical and follows the characteristic hard rhythm of a short dry season and a long rainy season, it lies at the north-south transition between the mountain savannah vegetation of the southern stretches of the Bamenda highlands and the equatorial rainforest of

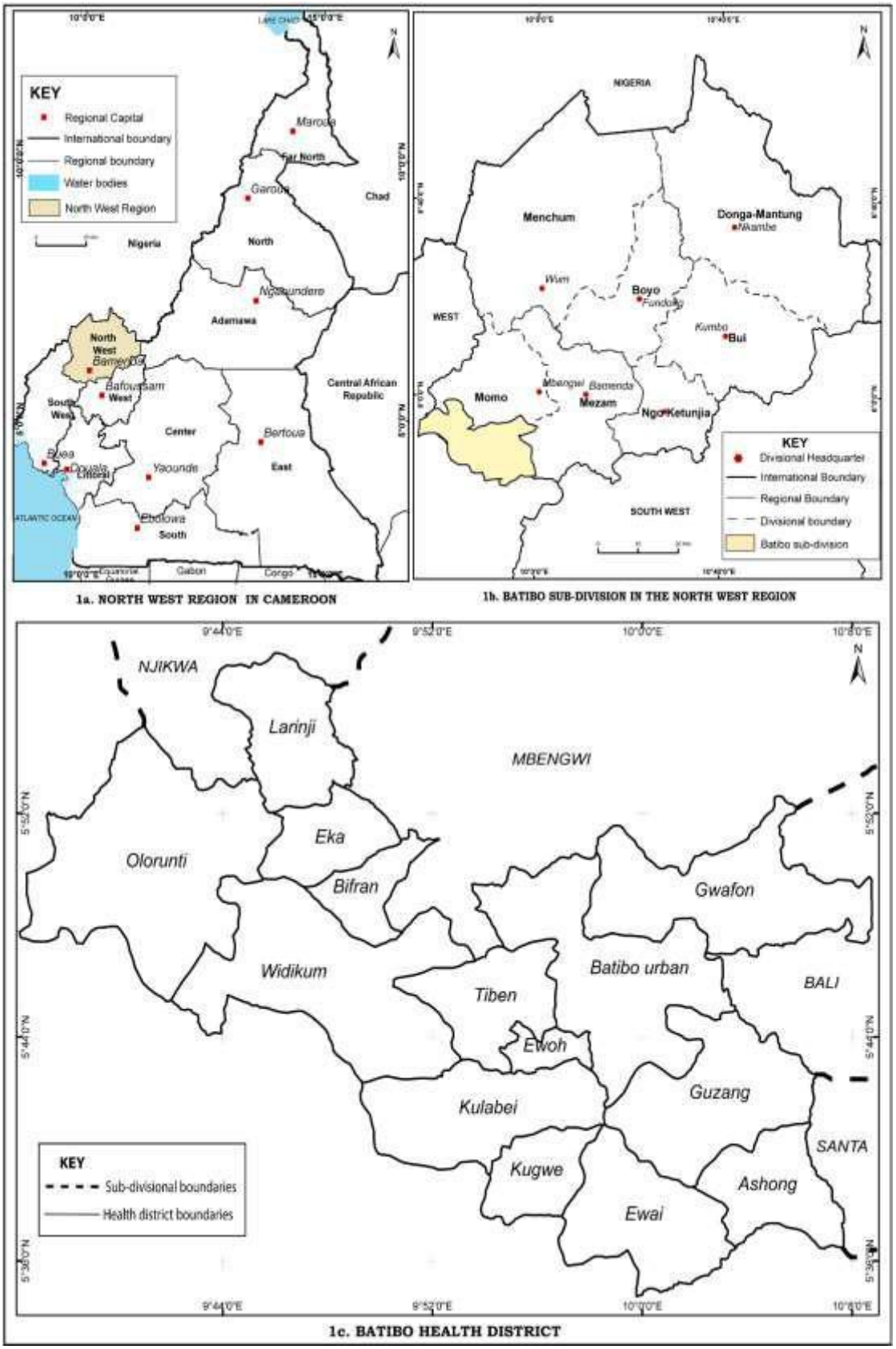

Figure 2. The location of the Batibo health district in North West Cameroon (Ministère de la Santé Publique du Cameroun, 2015; Carte Sanitaire National; https://www.dhis-minsante-cm.org/portal/index.html).

Table 1. The distribution of porcine and other livestock in the North West in 2005 (North West Development Authority (MIDENO), 2006; Baseline Study of the North-West Province, MINADER).

Division	Bovine	%	Porcine	%	Avian	%	Ovine/Caprine	%
Boyo	43661	12.8	4488	4.6	23429	5.8	53656	14.3
Bui	56010	16.4	8480	8.6	45200	11.2	33035	8.8
Donga Mantung	129754	38.0	13581	13.8	122114	30.3	159155	42.5
Menchum	62920	18.5	12918	13.0	61288	15.2	40772	10.8
Mezam	26937	8.0	25491	25.9	84448	21.0	25130	6.7
Momo	14745	4.3	21143	21.5	43300	10.9	46700	12.5
Ngoketunjia	6649	2.0	12450	12.6	22600	5.6	16350	4.4
Total	340676	100	98551	100	402379	100	374798	100

the Mamfe depression extending to the coastal lowlands of Cameroon. The people of the subdivision are the Moghamo who are believed to have originated in Widikum; further south of the area. Over 80% of the people are farmers growing mainly tubers like cassava, colocassia, cocoyam, and tree crops like plantain, banana, coffee and others. Animal husbandry is also important involving the keeping of porcine, caprine and avian, often in a free-range system. The tapping of raffia wine is also an important activity of the local people of Batibo.

Data collection and analysis

The study design was mainly co-relational in which epilepsy prevalence was compared with conditions, lifestyles and activities that may predispose people to risks of the disease. In that light, an attempt was made to correlate epilepsy prevalence with the distribution of porcine population. Porcine has been widely reported in the literature to be strongly associated with *T. solium* prevalence in developing countries. Data on epilepsy and *T. solium* were sourced from field survey with questionnaire, Batibo district hospitals records, and the Community Development and Epilepsy Foundation (CODEF). There was no comprehensive data on epilepsy neither at the Regional Delegation of Public Health in Bamenda, nor at the Divisional or District levels. Data on pig farming was obtained from the Regional Delegation of Livestock, Fisheries and Animal Industries for the North West of Cameroon. A total of 100 questionnaires were administered to household members in nine villages in the Batibo health district notably to find out the methods of rearing pigs and the position of pork in their diets. These nine villages reported the highest consultations for epilepsy at the Batibo district hospital and the questionnaires were administered in proportion to the number of epilepsy patients reported from each of them.

RESULTS

The pattern of porcine distribution in North-West Cameroon

The North West of Cameroon is a leading region in livestock farming in the country. In addition to the more common cattle, sheep and goat rearing, pig farming is rapidly gaining ground as the demand for meat increases everyday with urbanization. The Mezam and Momo divisions dominate the rest of the region in this activity probably because pork is an adopted delicacy for social ceremonies over beef and mutton, and the added demand coming from the city of Bamenda which has become the third city in the country in terms of population (BUCREP, 2010). The pattern of livestock distribution in the region is depicted in Table 1.

A survey of the porcine population in the region over six years corroborates the data carried in Table 1. While the porcine population has increased steadily in all the divisions since 2010, it contracted in the Bui and Donga/Mantung divisions. Overall, porcine farming is on the rise in all divisions of the region, though Mezam and Momo have stood out distinctly from the others in the activity. Figure 3 shows the increasing trend in porcine population by division in the region over a six-year period.

Although porcine farming has always been an important activity in Mezam and Momo divisions, the activity has experienced very exponential growth rates in the past decade. Whereas the urban influence may largely explain the trend in Mezam division, the trend in Momo division may be seen more from a cultural perspective wherein pork is the cherished meat at most social and traditional ceremonies. Figure 4 shows the repartition of porcine population in the North West of Cameroon. Even without the time dimension, the pattern concurs with Figure 3 showing the evolution of porcine population over a six-year period. Mezam, Momo and Ngoketunjia lead the region in pig farming.

Pattern of epilepsy in the North-West of Cameroon

The geographical pattern of epilepsy in the North-West Cameroon is difficult to ascertain because of the dearth of data on the ailment. At best, it is fragmentary and only hospital records and the reports of few non-governmental organizations are used to estimate the geographical pattern of the disease. No known full scale surveys on epilepsy in the region exist. However, the Cameroon Epilepsy Foundation (CEF) estimates the number of epilepsy sufferers in the region to be somewhere at 35000.

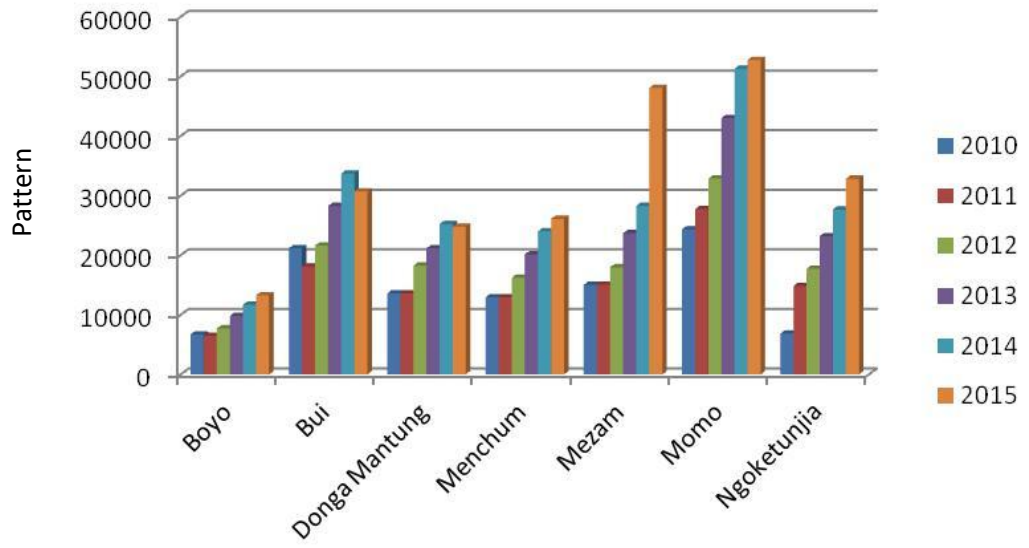

Figure 3. Pattern of porcine farming in NW Cameroon (North West Regional Delegation of the Ministry of Livestock, Fisheries and Animal Industries (MINEPIA) Annual Reports 2010-2015).

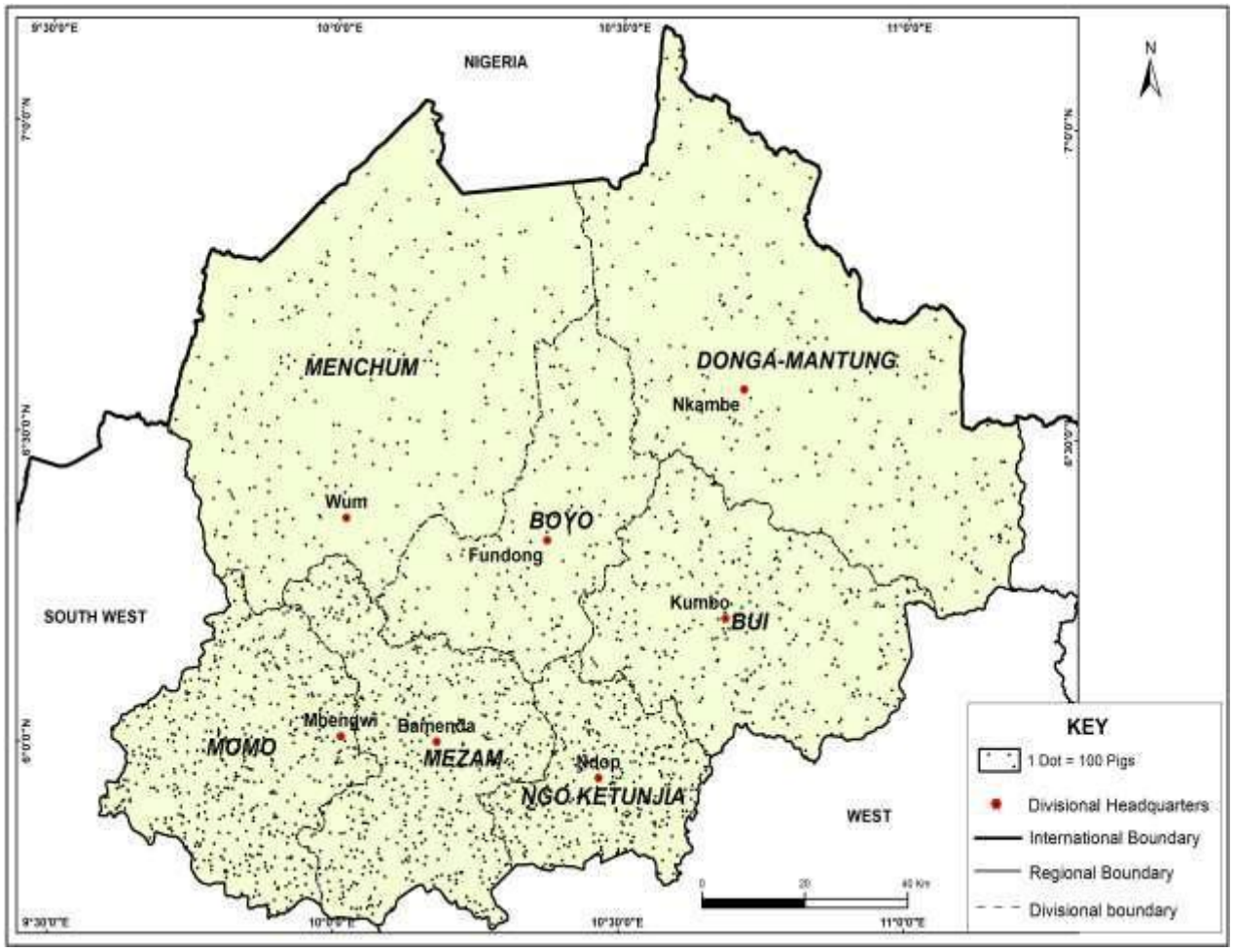

Figure 4. The distribution of porcine population in the North West of Cameroon, 2015 (North West Regional Delegation of the Ministry of Livestock, Fisheries and Animal Industries (MINEPIA) Annual Reports 2010-2015).

Table 2. Frequency of responses on livestock rearing and epilepsy (Fieldwork, August 2015).

Village	Pig	Goat	Fowls	Cattle	Total livestock	Epilepsy
Enyoh	9	4	6	-	19	12
Mefah	9	2	5	-	16	12
Guka	9	1	3	-	13	10
Mbunjei	12	3	5	-	20	07
Guzang	12	5	7	-	24	06
Njinyen	12	4	6	1	23	12
Ashong	12	3	5	2	22	14
Ambo	12	2	4	2	20	09
Kulabei	9	3	5	1	18	10
Total	96	27	46	6	175	92

Table 3. Frequency of responses on dominant meat (Fieldwork, August 2015).

Village	Pork	Goat	Fowls	Beef	Epilepsy
Enyoh	7	4	5	6	12
Mefah	9	2	4	5	12
Guka	1	1	3	3	10
Mbunjei	10	1	5	5	7
Guzang	12	3	4	7	6
Njinyen	8	4	5	6	12
Ashong	12	3	4	5	14
Ambo	11	2	4	4	9
Kulabei	8	1	3	5	10
Total	78	21	37	46	92

Whereas epilepsy is reported from all over the North-West, Batibo has consistently been depicted in various empirical as well as scientific surveys as the locality with the highest reported cases of the disease (Elliot et al., 2013; Njamnshi, 2009a, b). In the absence of reliable and consistent data on the distribution of epileptics in Batibo sub-division, a questionnaire survey provided the following trend for the disease in association with common livestock. Porcine stands out as the dominant livestock type reared in the locality. Although a strong statistical association cannot be established between porcine farming and epilepsy, it is sufficiently evident that it is the dominant type of livestock farming in the locality (Table 2). The data in Table 2 is corroborated by that in Table 1 where Momo division peaks the rest of the region in porcine production.

As indicated earlier, pork is the dominant meat eaten in regular daily meals, socio-cultural ceremonies like festivals, dances, marriages, births, and deaths. Lying at the transition between the highland savanna and the lowland forest where average temperatures tend to be higher than in the highlands, most of the Momo division does not present the best bovine farming prospects because of the risks of a pest like the tsetse fly common in such ecosystems. Table 3 shows the trend of responses on the dominant types of meat eaten in the area with pork dominating.

Surveys across Cameroon have demonstrated the strong relationship between porcine farming and cystercecorsis (Zoli et al., 2003; Assana et al., 2001; Prouedet et al., 2002; Shey-Njila et al., 2003). The intensity of this relationship is determined by local hygiene, sanitation and sociocultural factors like feeding pigs by defecating directly into their pens, weak technical capacity to detect and treat *T. solium* carriers, inadequate meat inspection and the consumption of poorly cooked pork. Figure 5 illustrates the relationship between the frequency of pork consumption and that of epilepsy in the interviewed population of the Batibo health district. Except for Guka, Guzang, Mbunjei and Njinyen, the consumption of pork and reports of epilepsy tend to move in the same direction.

To ascertain this relationship statistically, Kendall's tau for rectangular table (Table 4) was used.

Kendall's tau = $3*tau*\sqrt{n(n-1)} / \sqrt{2(2(n)+5}$

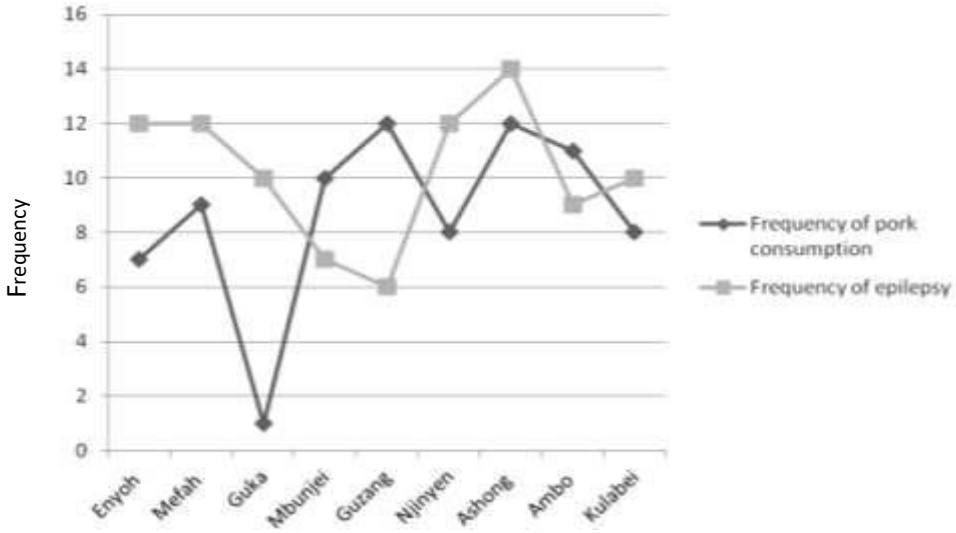

Figure 5. Pork consumption of pork and the frequency of epilepsy in selected villages in Batibo sub-division.

Table 4. Kendall's tau for rectangular tables.

Village	Rank for frequency of epilepsy	Rank for frequency of pork consumption	Concordant rank	Discordant rank
Ashong	1	1	7	0
Njinyen	2	6	2	4
Enyoh	2	8	1	5
Mefah	2	5	2	3
Guka	5	9	0	4
Kulabei	5	6	0	3
Ambo	7	3	1	1
Mbunjei	8	4	0	1
Guzang	9	1	-	-
Total ranks	-	-	13	21
-	-	-	13-21/13+21 = -0.235	

3*-0.235*√9(9-1) / √2(2(+9) +5 = -0.881

Kendall's tau is positive when the number of concordant pairs exceeds the number of discordant pairs and is negative when the number of discordant pairs exceeds the number of concordant pairs.

DISCUSSION

The obtained Kendall's tau of -0.881 indicates that the number of discordant pairs exceed the concordant pairs with the implication that there is a strong negative correlation between the reported frequency of epilepsy and the frequency of pork consumption in the areas surveyed at 5% confidence level.

There is yet no unanimity among researchers on the association between *T. solium* cysticercosis and epilepsy. However, there is abundant evidence from the literature that *T. solium* and epilepsy are positively correlated in many places around the world. However, what many of these studies seem to agree upon is the high prevalence of *T. solium* cysticercosis in porcine farming and pork eating populations. This relationship has been systematically reported in various studies on Cameroon and Africa (Zoli et al., 2003; Assana et al., 2001; Pouedet et al., 2002; Shey-Njila et al., 2003; Nguekam et al., 2003; Thomas et al., 2016; Vondou et al., 2002). Incidentally, epilepsy prevalence is also generally higher in areas associated with high rates of porcine farming. Batibo sub-division is one of such areas amongst many others in the North West and West of Cameroon.

Whereas the works of Zoli et al. (2003), Thomas et al. (2016), Garcia et al. (1993, 2003), WHO (2012), Willingham (2002), Praet et al. (2009) and Cruz et al. (1989) are conclusive on *T. solium* cysticercosis as a cause of epilepsy in general, Dongmo et al. (2004), Elliot et al. (2013) and Mazigo et al. (2013) not only doubt the epidemiological relationship between cysticercosis infection and epilepsy, but indicate that there is severe knowledge deficiency in sub-Saharan Africa on the cause and magnitude of the association. Although Elliot et al. (2013) conclude that there is no likelihood of cysticercosis causing the high prevalence of epilepsy in Ngie sub-division of the North-West of Cameroon, their study is limited by ignoring the fact that neurocysticercosis is a major cause of focal epilepsy meaning that their sample was faulty by lumping both generalized and focal epileptics together. This methodological problem seems to be the major reason for the numerous discrepancies in research results on the association between *T. solium* cysticercosis and epilepsy around the world though it is also possible for the disease to have different aetiologies in different places. In spite of the lack of general consensus on the *T. solium* cysticercosis origins of focal epilepsy, advancements in medical science have produced drugs capable of controlling seizures in most patients. Whereas modern medicine only provides epilepsy control, some epileptics eventually get completely free of seizures. A large number of traditional practitioners also provide treatments for epilepsy though their efficacy is not certain.

Conclusion

The results of this study negating the association between *T. solium* and epilepsy should be taken with caution because of the paucity of systematic data on epileptics in the North-West in general and in Batibo sub-division in particular. However, the strength of the study is its attempt to pattern porcine farming and epilepsy in the region geographically. Being one of the neglected diseases in clinical science practice, epidemiological surveys which map porcine farming can be a pathway to community participation in the control and prevention of *T. solium* in many localities. Pig farming in the rural areas of the region is traditional and the transmission of the parasite from the pigs to man and vice-versa is facilitated by the practice of free range pig rearing and open air defecation in pigpens, “latrines” by some households, clandestine slaughtering of pigs, lack of trained and qualified meat inspectors and the poor detection of *T. solium* by the rudimentary and rampantly used lingual palpation technique.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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