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Original Contribution

West African Cattle Farmers' Perception of Tick-Borne Diseases

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Abstract: Worldwide, cattle production is struggling to face the negative impacts caused by ticks and *Rhipicephalus (Boophilus) microplus* is one of the most harmful ticks for livestock. Most of the people in West Africa depend on cattle farming and subsistence agriculture. The presence of ticks on cattle is a major problem faced by smallholder farmers who fight for their livelihood. National and regional tick control programs could assist these rural communities in protecting their livelihoods against ticks and tick-borne diseases, but only if they take into account the targeted herders and their perception on cattle management and tick control. This paper aims to provide a better insight in the socio-economic characteristics of Beninese cattle farmers, and their perception on tick burden, as well as to document common tick control strategies. Different tick species and their seasonality are well understood by cattle herders. For tick control, many still use manual tick removal, especially in the north of the country. The high cost of acaricides, the lack of financial means of African farmers, and of the local stockbreeders in particular, limits the use of acaricides in livestock breeding in Benin. While aiming to increase the meat or milk production of their animals, stockbreeders who can afford it sometimes turn to an abusive use of acaricides, which might in time lead to an increase in tick resistance. This study remains one of the rare studies to report extensively on the perceptions of West African cattle herders.

Keywords: Ticks, Tick control, Cattle herders, Perception, Survey

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Introduction

Worldwide, cattle production is struggling to face the negative impacts caused by ticks. Tick burden varies from one ecological region to another. In some areas, the damage rate on livestock can reach 80% (Stachurski 1989). *Rhipicephalus (Boophilus) microplus* is one of the most harmful livestock ticks (FAO 1990) and appeared for the first time in Asia (Barré and Uilenberg 2010). Although its first observation in Benin was only a decade ago, it has spread rapidly over the country from South to North (Madder et al. 2011). *R. microplus* withstands common acaricides and has a short life cycle (Guerrero et al. 2007). On top of this, it is a successful vector of *Babesia (B.) bigemina* and *B. bovis*.

Infection with *Babesia* can lead to a loss of productivity and even to the death of the infested animal. The economic losses generated by ticks and tick-borne diseases are significant. They can amount to an increase of 36% of working time, a reduction of 20% in meat production, a reduction of 16% in milk production, a mortality rate of 11%, a depreciation of 5% of skin value and a reduction of 5% in the time of draught power (Sutherst and Kerr 1987; Dossou-Gbete et al. 2006). The high cost of acaricides, the lack of financial means of African farmers, and of the local stockbreeders in particular, limits the use of acaricides in livestock breeding in Benin. While aiming to increase the meat or milk production of their animals, stockbreeders who can afford it sometimes turn to an abusive use of acaricides, which might in time lead to an increase in tick resistance.

Most of the people in Benin depend cattle farming and subsistence agriculture. In this setting, the presence of ticks on cattle is a major problem faced by smallholder farmers who fight for their livelihood. It is thus urgent and important to act in order to assist farmers who might not have the adequate techniques to keep their cattle safe. The management of these ectoparasites must take into account the point of view of cattle herders in the definition of the tick control strategy. Especially when the goal is to maintain or reach endemic stability of tick-borne diseases, there is a need to incorporate indigenous knowledge.

In this context, we want to refer to past campaigns for tick eradication that faced serious problems in order to reach their objectives, in part because they had been drafted with too little consultation with farmers. The eradication of *R. microplus* cost the life of state veterinarians in the USA because the control measures were not accepted by the targeted subsistence farmers (Strom 2009). In the Caribbean, millions of dollars were invested in the struggle for the eradication of *Amblyomma* ticks (Pegram 2010; Walker 2011a). After an initial success of this campaign, tick reintroduction unfortunately occurred and was attributed to migratory egrets, birds living in close contact with cattle (Ahoussou et al. 2010). It can be a wasteful and dangerous business to plan control and eradication campaigns without a sufficient insight in the reality of the targeted farmers' communities.

As it stands, the available information on practices of tick control by the local population in Benin is sparse and fragmented. The objectives of the present study are thus (1) to obtain a better insight in the socio-economic characteristics of Beninese cattle farmers, (2) to assess their perception concerning tick burden caused by *Amblyomma variegatum* and *Rhipicephalus microplus* and (3) to document the local tick control strategies and their perceived effectiveness. We aim to provide a knowledge base for the development of upcoming livestock programs.

Materials and Methods

Study Area

The study was carried out in April 2013 in Benin, West Africa, spanning different ecological regions (FAO 2010) and three administrative regions. The departments of Alibori and Borgou are for the larger part in the ecoregion characterized by tropical moist deciduous forest, and the department of Mono is within the tropical rainforest zone (Fig. 1).

In the department of Alibori, more than 70% of the total population depends on farming for a living (CountrySTAT 2016). The climate is hot and dry, while the vegetation is dominated by woodlands composed mainly of *Isoberlinia* species (White 1983). Rain is unimodal, from May to October, with a dry season lasting 6 months from November to April. Annual pluviometry varies between 700 and 1000 mm. The dominant ethnic groups in this department are Bariba (32.6%), Fulani (22.1%), Dendi (18.2%) and Yoruba to a lesser extent. In the department of Borgou, 67.92% of the population are farmers (CountrySTAT 2016). The climate is sub-humid with a unimodal rainfall amounting to 1200 mm. The occurring vegetation is similar to the woodlands of the Alibori region. Bariba

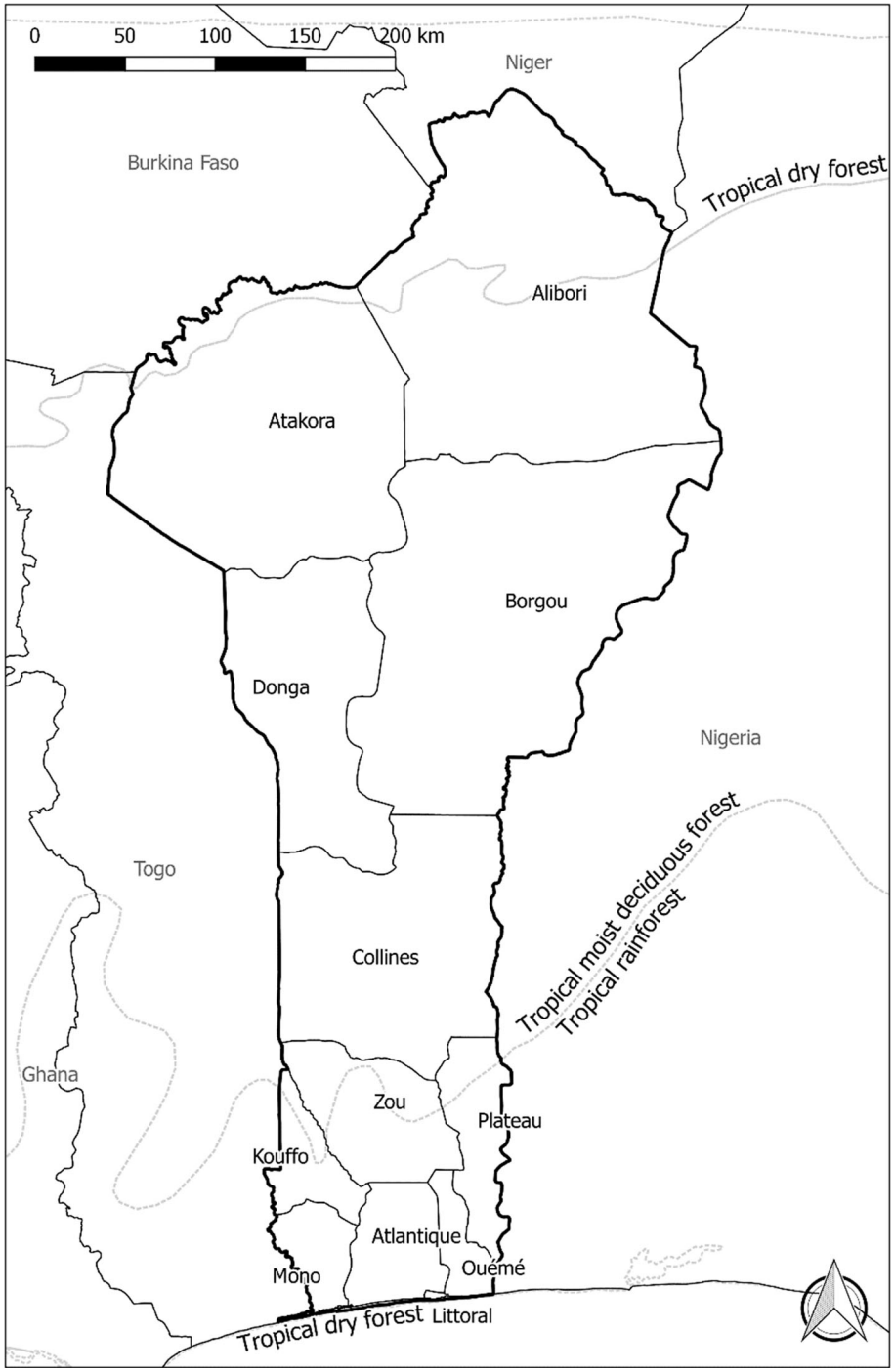

Fig. 1. Overview of the study area.

(40.4%), Fulani (29.8%) and Yoruba (6.0%) are the prominent ethnic groups.

The department of Mono is located in the southern part of the country. Here, 65% of the population are farmers (CountrySTAT 2016). In contrast with the other two departments, it has a humid climate, featuring two rainy seasons (March to June and September to November) with an average pluviometry ranging from 1000 to 1200 mm. The vegetation is mainly made up of grassy savanna, marshy meadows and mangroves, interspersed with patches of deciduous forests (White 1983). Dominant ethnic groups are Sahoué (39.9%) and Kotafon (21.3%).

The two northern departments are typical herding regions, while cattle herding is rare in the south, where the rural population is more dedicated to agricultural crops. During the last extensive agricultural census, the department of Alibori counted 720,100 heads of cattle, while Borgou contained 646,000 heads of cattle. For the department of Mono, this figure was 15,200 cattle heads (Direction de l'élévage 2014).

Data Collection

Within each department, 30 cattle herds were selected as sampling units for the survey. A snowball sampling, also known as referral sampling, was used. Starting from the administrative centre of the department, one farmer or cattle herder was interviewed, and the interviewed person suggested the next person to be included in the study. This was repeated until a total number of 30 sampling units were

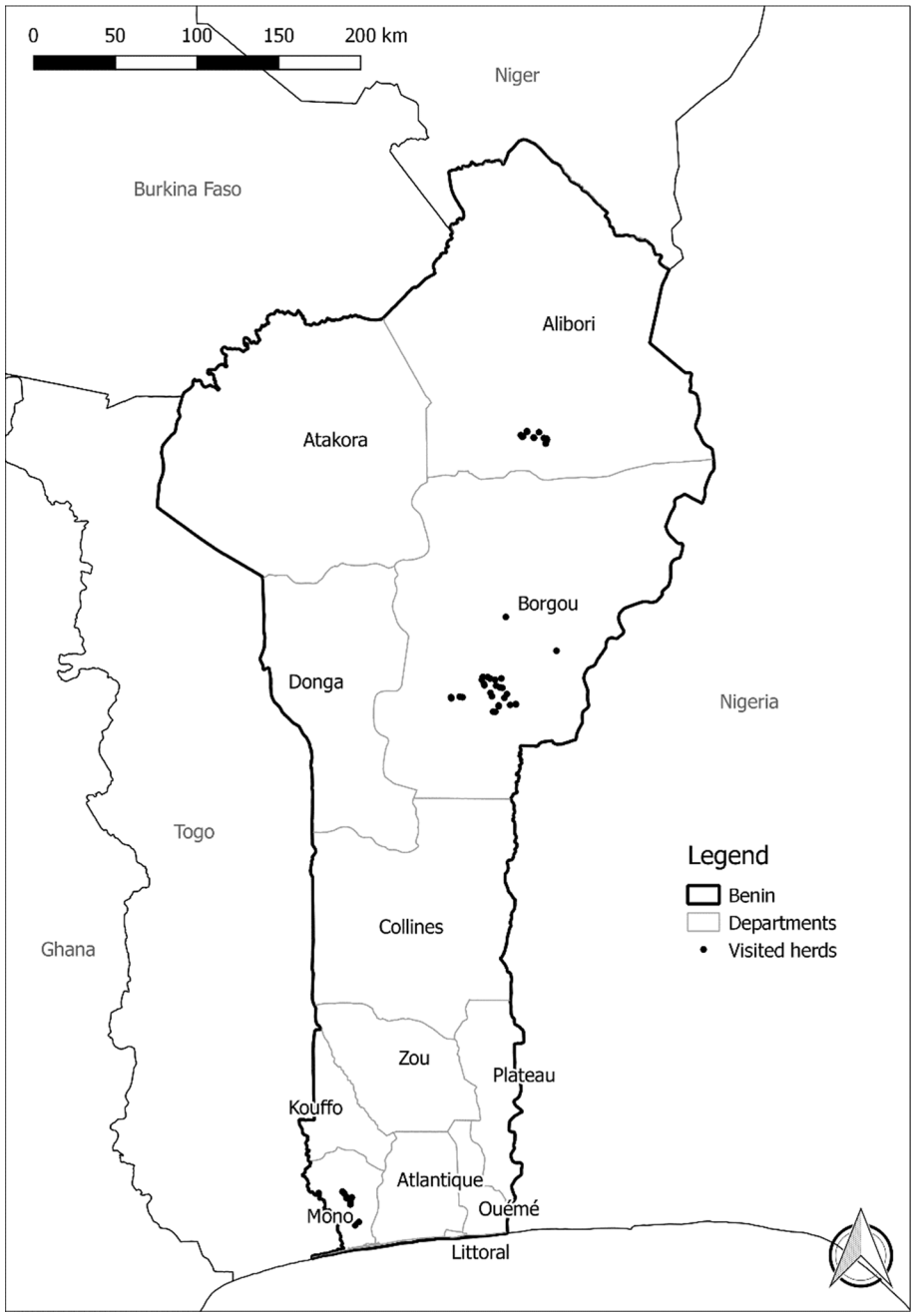

Fig. 2. Localization of the visited herds.

reached per department. For each herd, general information about the herder was collected, and specific issues related to ticks and tick control were discussed. This exchange was made mainly with the cattle herder, but also to a certain extent with the farmer, depending on his level of implication in breeding issues. This sampling technique is often used in sociological studies when it is difficult to locate or to make contact with the sampling population.

We collected data from three departments in Benin (Fig. 2). For logistical reasons, herders from a limited area, roughly corresponding with a municipality, were interviewed in all three departments. Covering the entire department in these remote areas would have required an unreasonable amount of time and budget.

In total, 54 questions were asked on topics ranging from personal information (age, education and professional activities), tick burden and tick control. The questionnaire form (in French) was included as supplementary data (S1). In order to avoid confusion amongst tick species, the discussion was supported by pictures. All farmers were asked to indicate the months of the year during which tick infestation was present, both for *Amblyomma* as *Rhipi-*

Table 1. Main Demographic Characteristics of Respondents.

Factor	Class	Alibori	Borgou	Mono	Total
Ethnic group	Fulani	22	24	28	74
	Gando (Bariba)	8	2	–	10
	Bariba	–	2	–	2
	Nagot (Yoruba)	–	1	–	1
	Dendi	–	1	–	1
	Sahoué	–	–	2	2
Gender	Female	1	1	3	5
	Male	29	29	27	85
Age	≤ 25	4	–	3	7
	26–30	2	3	3	8
	31–40	7	7	9	23
	≥ 40	17	20	15	52
Household size	1–5	3	6	8	17
	6–10	8	11	14	33
	11–15	9	7	5	21
	≥ 15	10	6	3	19
Education level	No	26	16	15	57
	Primary	3	11	12	26
	Secondary	1	2	3	6
	Advanced	–	1	–	1
Primary occupation	Cattle herding	29	27	27	83
	Agriculture	1	1	3	5
	Housework	–	1	–	1
	Scholar	–	1	–	1
Herd size	20	11	8	6	25
	21–49	14	16	6	36
	50–100	4	5	12	21
	≥ 100	1	1	6	8
Years of breeding experience	≤ 5	–	5	10	15
	6–10	–	2	4	6
	11–25	7	3	11	21
	25–40	9	8	4	21
	≥ 40	14	12	1	27

cephalus Boophilus species. Respondents were asked about their preferred tick control method. When chemicals were used, the name and the quantity of acaricides bought for a single herd treatment were recorded. The dose per animal was obtained by dividing the purchased quantity by the number of animals reported as treated. No mention of commercial names was made; only the active component was recorded along with the required doses. The respondents were also questioned on what they perceive as the main reasons for ineffective tick control.

Data Analysis

First, cattle herders were divided into socio-economic groups using a hierarchical clustering (HC) using Ward's linkage based on age, household size, breeding experience and herd size. The number of clusters was determined by the broken stick method on a scree plot, reflecting the within-group variance. Main characteristics were calculated for each group.

Afterwards, differences in perception on tick presence, tick control and tick burden were studied per socio-economic group and per department. All statistical analyses were performed using R 2.15.3 software (R Core Development Team 2016).

Results

Characteristics of Respondents

Details on the demographic characteristics of the respondents are listed in Table 1. The surveyed cattle farmers were of different ethnic groups, but the large majority were Fulani (82%, $n = 74$). Smaller ethnic groups were Gando, a subgroup of the Bariba (11%, $n = 10$), Bariba (2%, $n = 2$), Nagot (1%, $n = 1$), Sahoué (2%, $n = 2$) and Dendi (1%, $n = 1$). Given their high proportion within the population in the northern departments and the traditional character of Bariba and Fulani as, respectively, cattle owners and cattle herders, it was not surprising that the majority of the interviewed cattle herders in the North were identified as Fulani. More noteworthy was that in regions in the north, as well as in the south, cattle herding was almost exclusively done by Fulani. They comprised between 73 and 93% of the interviewees in all three departments, while they represent only 22, 30 and less than 3 of the population in, respectively, Alibori, Borgou and Mono.

There were only a few women amongst the interviewees, and the majority of all interviewees was more than 40 years of age. Households tended to be larger in Alibori than in the departments of Borgou and Mono, where the majority of interviewed households counted less than 10 members. Very few farmers have received a basic education, while a large proportion (63%, $n = 57$) admitted to never having attended school. The education level was lowest in Alibori. Cattle herding was the main occupation of most interviewees. Agriculture occupied a less important part of their time, although it was generally mentioned as a secondary occupation. Herd sizes were increasing from north to south, with Mono having generally larger herds than Alibori and Borgou. Overall, herds larger than 100 heads were relatively rare. Most of the interviewees had a lot of experience in cattle herding: more than 80% (83%, $n = 75$) had more than 5 years of breeding experience and more than 70% (77%, $n = 69$) had more than 10 years of experience. A majority of the interviewed cattle herders started tending to animals before they were 10 years old. In Alibori and Borgou, the majority of the cattle herders had more than 25 years of experience, in contrast with Mono, where

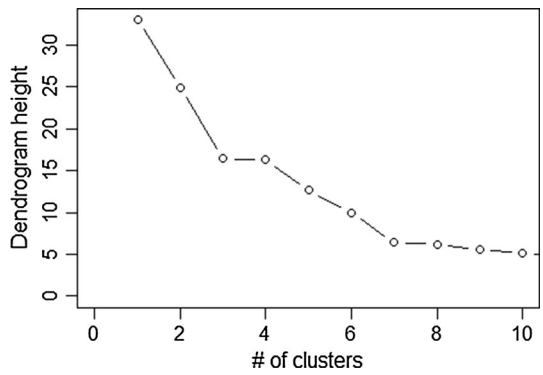

Fig. 3. Scree plot for the clustering of the interviewed cattle herders.

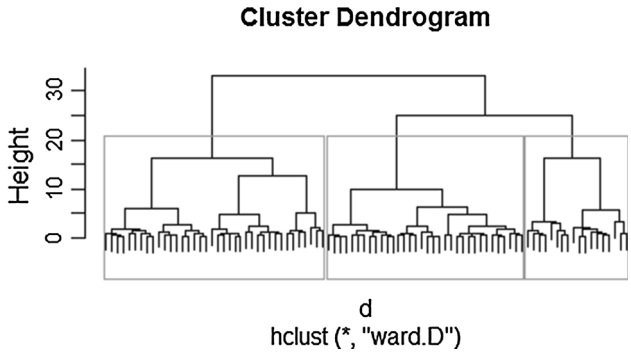

Fig. 4. Cluster diagram for the clustering of the interviewed cattle herders.

the majority had less than 25 years of experience. The lower number of years of experience was not caused by a younger age of the respondents, but because the respondents started cattle herding at a later age.

Socio-Economic Groups

According to their socio-economic characteristics, three main groups of cattle herders could be distinguished (Figs. 3 and 4).

Group 1 was the most important in size (38 individuals), followed by group 2 (34 individuals) and group 3 (18 individuals) (Table 2). Group 2 was dominant in Alibori and Borgou, while the majority of the interview herders in Mono were classified in group 1. Group 3 was mainly present in Alibori, to a lesser extent in Borgou and very marginal in Mono.

Group G1: Stockbreeders with Short Experience and Large Herd Size

The average age in this group was 47 years (SD = 15 years). The average number of years of experience is 10 years (SD = 8), implying that the majority of herders in this group did not start cattle herding in their early youth. The average herd size was at 65 heads the highest of all groups. The household size was with nine people (SD 5) the lowest of all three groups.

Table 2. Description of Different Socio-Economic Groups.

	Group 1	Group 2	Group 3
N	38	34	18
Age			
Mean	47	38	62
SD	15	10	15
Years of breeding experience			
Mean	10	37	56
SD	8	9	18
Household size			
Mean	9	11	20
SD	5	5	10
Herd size			
Mean	64	26	41
SD	48	13	30
N per Department			
Alibori	3	16	11
Borgou	9	15	6
Mono	26	3	1

Group G2: Stockbreeders with Medium Age, Medium Experience Level and Medium Herd Size

The stockbreeders of this group appear to be the youngest. Although the mean age was 38 (SD = 5), the average number of years of experience was 37 years (SD = 9). These herders learned caring for animals as small children. The household size was similar to the size of group 1, with 11 members (SD = 5), but the number of animals in the herd was considerably lower, with 26 animals (SD = 13) the lowers of the three groups.

Group G3: Stockbreeders with Long Years of Breeding Experience and Small Herd Size

The stockbreeders of this group seemed to be the oldest, with an average age of 68 years (SD = 15). The number of

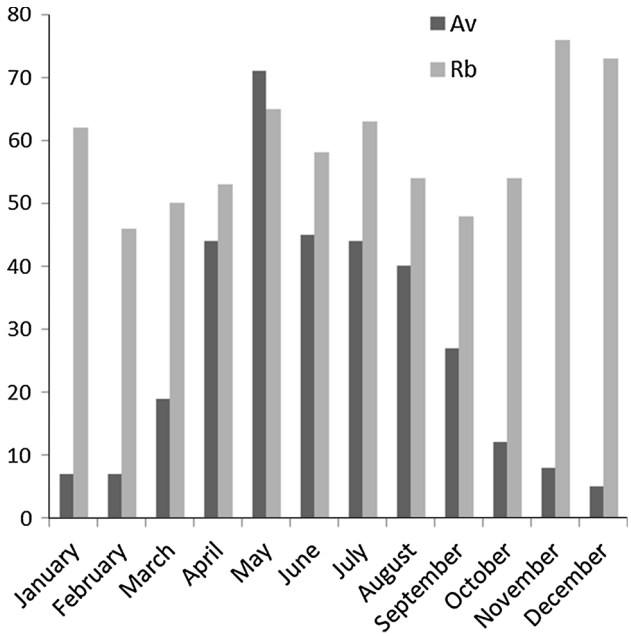

Fig. 5. Seasonality in the presence of two main tick species: (i) Av: *Amblyomma variegatum* and (ii) Rb: *Rhipicephalus (Boophilus)* spp.

Table 3. Tick Genus Perceived as Causing most Damage per Department.

Department	*Amblyomma*	*Rhipicephalus*
Alibori	30	0
Borgou	18	12
Mono	20	10
All	68	22

Table 4. Impact of Tick Infestation on Animal Health and Animal Production.

	All	Alibori	Borgou	Mono
General weight loss	78	70	83	80
Increase in skin infections	77	90	83	57
Decreased milk production	71	73	93	47
Decrease in adult weight	66	80	93	23
Increased limping	66	70	80	47
Decreased fertility	28	30	53	0

years of cattle herding experience (average 56, stdev = 18) indicates that this group also started attending to cattle at a very young age. The average of herd size was 41 heads with a relatively high standard deviation of 30. In this group, the household size was the largest with 20 members on average (SD = 10).

Spatial and Temporal Tick Distribution

All interviewed cattle herders recognized and named all tick genus present in the area. The names of ticks in Fulani language are 'Coti', 'Douchev' and 'Kidou', respectively, for *Amblyomma variegatum, Rhipicephalus (Boophilus)* spp and *Hyalomma* spp.

While *A. variegatum* is reported to be more abundant from March to June, *Rhipicephalus (Boophilus)* is observed during the whole year with the appearance of two peaks one from March to June and the second from October to January (Fig. 5). Overall, the majority of the farmers were aware of the seasonal peak in abundance for *A. variegatum* from March to June.

However, the perceived seasonality of *R. Boophilus* differed in the three departments. The uniform abundance of *R. (B.) microplus* year round was related by 100% (30/30) of the respondents in Alibori versus 57% (17/30) and 20% (6/30), respectively, in Borgou and Mono.

About 76% of the interviewees mentioned *A. variegatum* as the tick that caused most damage, while *R. (B.) microplus* was mentioned by 25% of respondents. The perceived effect of tick infestation was listed per department in Table 3.

For the stockbreeders of Alibori, *A. variegatum* was systematically perceived as the tick causing most damage (Table 3). In Borgou, the cattle herders perceived the two ticks as equally damaging. This perception was similar to that of the cattle herders in Mono.

Tick Burden

The interviewed cattle herders listed a number of effects tick infestation can provoke (Table 4). The most common effects on the infested animals were general weight loss and skin infections, which were reported by, respectively, 78 and 77% of all cattle herders. Also milk production decreases, and weight loss and limping were reported by, respectively, 71, 66 and 66% of all herders. Decreased fertility was reported by a minority (28%) of cattle herders.

Tick Control

Two main types of tick control could be distinguished (Table 5); first, conventional veterinary care consisting in the use of acaricides, being the most frequent (48/90). The second type of tick control is the traditional method by manual tick removal, used by 38 out of 90. On rare occasions (1/90), non-conventional methods were used: respectively, the use of a mixture made of palm oil and salt, use of insecticide, or also the use of mixtures made from local plant species (*Ocimum gratissimum*, *Tephrosia vogueli*, *Lantana camara* et *Hyptis suaveolens*). A small part of breeders (2/90) do not take any action against tick infestation.

The acaricides used were based on diverse active components, being predominantly amitraz (29/90), alpha-cypermethrin (17/90) and in rare instances cypermethrin (1/90) or flumethrin (1/90). Individually, each of the specified acaricides was less frequent than traditional manual tick removal.

When asked for the main problems related to tick control, herders listed the hurdles they faced depending on the method they used. Manual tick removal was considered to be strenuous labour and dangerous. It is indeed quite difficult to handle and restrain adult cattle for more than a couple of seconds, and many herdsmen got injured when

Table 5. Methodology Used for Tick Control, and Number of Users per Department.

Method	All	Alibori	Borgou	Mono
Manual	40	18	22	0
Amitraz	29	11	7	11
Alphacypermethrin	17	0	0	17
Cypermethrin	1	1	0	0
Flumethrin	1	0	0	1
Manual & Palm oil & Salt	1	0	0	1
Manual & Insecticides	1	0	1	0

Table 6. Reported Efficacy, Dosage and Cost of the Different Products Used for Tick Control.

Product	*N*	Reported efficacy of method					Dose (ml/l of water)		Cost/animal	
		No answer	Very poor	Poor	Good	Very good	Required	Reported	FCFA	EURO
α-permethrin	17			1	8	8	1	4.35	208 341	318
Amitraz	29		1	1	6	21	2	12.21	111 120	170
Flumethrin	1					1	0.1	0.1	446	0.67
Cypermetrin	1					1	1	5.38	208	0.32
Insecticide	1					1	–	–	31	0.05
Manual tick removal	38		15	1	1	21	–	–	–	–
Palm oil + salt*	1				1		–	–	–	–
No action	2	1			1		–	–	–	–

The products were ranked by decreasing cost.
* = Palm oil + salt and also mixtures made of local plant species.

hit by a kicking leg of the restrained animal. Farmers who used traditional methods were not entirely confident in the accompaniment of the veterinary services. Also, they considered the costs for chemical tick control too high to be accessible to them.

At the opposite part of the spectrum, a number of farmers worked in close collaboration with veterinary services and used chemical tick control; these farmers did not perceive the constraint of the animal or the cost of treatment as an insurmountable problem.

The efficiency of different types of tick control as perceived by farmers is for amitraz, alphacypermethrin and manual removal methods, respectively, 93.1, 94.1 and 60.5% (Table 6). Chemical methods were more expensive, at least thirty times more expensive than traditional and non-conventional methods (usage of insecticide) (Table 6); the most expensive acaricide flumethrin is two times more expensive than the cheaper amitraz. Unfortunately, we observed that the required doses were not respected by the farmers; an overdosage for all acaricides is common (Table 6).

Discussion

Demographic Characteristics of Cattle Herders

Like in other countries of West Africa (Somda et al. 2004; Alkoiret et al. 2009; Abdoukarim et al. 2013), Fulani are the major cattle breeders in Benin, both in the northern and the southern regions. This ethnic group is also referred to as a socio-professional group. They are specialized in cattle farming, and breeding is their major and sometimes unique activity. For the present study, 81% of the sampled cattle breeders were Fulani and 11% were Gando. Although Gando are a subgroup of Bariba, they are very close to Fulani in their ways and customs. Although they are largely involved in cattle herding (Alkoiret et al. 2009), agriculture and cattle herding have the same importance for Gando. The cattle herders also comprehended four socio-cultural groups to a smaller degree, being Bariba (2.11%), Dendi (1.11%), Nagot (1.11%), Sahoue (2.11%).

It is true that the questionnaire made no distinction between cattle owners, cattle herders, seasonal workers and

occasional help from relatives or short-term paid animal caretakers. The idea that mainly children are responsible for the care of the animals, however, is not conform to reality. Children are deployed caretakers on a temporary and ad hoc basis, and as family support, but never carry a long-term responsibility for the cattle herd. It is on the contrary quite common for a cattle owner to dedicate long-term (i.e. multiple years) management of a cattle herd to a designated cattle herder. In the present study, the interviewee corresponded with the person taking responsibility and management decisions for the sampled herd.

Most of the respondents were more than 40 years old, like was also the case in Zimbabwe (Sungirai et al. 2016). Their long experience of cattle herding, at least 30 years of practice, makes their perceptions reliable, and it is thus not surprising that all respondents succeeded in recognizing and naming the prevailing ticks. They also had a clear idea on seasonality and intensity of tick infestation. This practical knowledge of ticks stood in sharp contrast with the lack of basic education for most farmers. Sungirai et al. (2016) indicated that knowledge on tick-borne diseases (TBDs) and tick control were more accurate with an increasing level of education and training courses for communal farmers in Zimbabwe. This was also implied by Moyo and Ferguson (2010) and Sahibi and Rhalem (2007) for farmers living in rural areas of, respectively, the Eastern Cape province (South Africa) and Morocco. Although tick burden was studied in greater technical detail in the study by Sungirai et al. (2016), this paper adds valuable information, as it is one of the rare studies to report local perceptions about tick burden on Beninese cattle. The majority of the animal disease control programs were prepared by the veterinary services without local cattle herders implication. Therefore, the present results are a base for upcoming livestock development programs.

Cattle herder groups were determined based on herd size and age. These characteristics were also determinant in classifying herders in previous studies in the districts Ouake and Gogounou in North-East Benin (Alkoiret et al. 2009, 2011). Sampled farmers succeeded in distinguishing the *Amblyomma* from the *Rhipicephalus* genus. The farmers' knowledge appeared good enough to support conclusions on the remainder of the questions asked.

Seasonal Abundance of Ticks

Whatever the department or the hierarchical group, perceptions clearly revealed that *A. variegatum* is likely to manifest from March to May. Biguezoton et al. (2016) noticed a similar result in Burkina Faso, matching the abundance peak to the rainy season. In Benin, the positive correlation between pluviometry and level of infestation by *Amblyomma variegatum* was pointed out by Farougou et al. (2006, 2007), although an extreme increase in pluviometry did not lead to an increase in tick abundance (Farougou et al. 2006).

Concerning the seasonality of presence of *R. (B.) microplus*, a continuous presence of the tick was reported. This concurs with the results obtained in Alibori by Dossou-Gbete et al. (2006). The perceptions of steady presence appear to vary within the study area along a longitudinal gradient. The farmers from Alibori perceived a steady presence of the tick. This opinion was shared by a minority of the farmers in Mono. This is in contrast to a recent publication (Biguezoton et al. 2016), where the presence of this tick was reported year round. The farmers in Borgou had mixed opinions.

The precision of tick identification for immature stages, which can even pose a challenge to scientists in the absence of microscopes or molecular tests, might intervene with a truthful perception of abundance. Unfortunately, the available information on temporal variation in abundance is focused on adult ticks. To our knowledge, no studies have been done in West Africa on the abundance of immature stages in relation to the environment. Further research could document this in more detail, as well as investigate the population dynamics of the species in relation with abiotic factors such as temperature and pluviometry, and herd management determined by herd size and herding experience (Léger et al. 2013).

Another point that might affect the perception of abundance would be the transhumance practiced, especially by cattle herders in the northern part of the country. Herds from the drier northern regions migrate south during the dry season towards more humid areas, not only more suitable for grazing, but also for tick survival.

Perception of Tick Burden

All cattle herders reported that tick infestation led to negative effects on animal health and animal production. Ranked from high to low frequency, this included widespread skin infections, limping and weight loss, and to a smaller extent loss of milk production and decreased fertility. Death due to tick infestation was reported in a very limited number of cases. Our results confirm the findings

of Dossou-Gbete et al. (2006) in northern Benin. Local cattle herders mainly hold the *Amblyomma* genus responsible. *Amblyomma* ticks (and their rostrum) are also considerably larger than ticks of the *Rhipicephalus* genus (Farougou et al. 2007; Biguezoton et al. 2016). This is probably why *A. variegatum* was perceived as the most harmful tick in rural communities. The same study, as well as ours, found that vector-borne diseases were not listed amongst the results of tick infestation. It is clear that limping and skin infections are more visible and easily measurable than fever and other symptoms of infectious and parasitic diseases. Their effect on animal production is however not negligible, as *A. variegatum* is a vector for *Erlichia ruminantium*, which has been detected in 10% of *A. variegatum* adults in Benin. *Rhipicephalus (B.) microplus* is an effective vector of red-water and gall sickness and is considered the tick causing the highest economic losses where it occurs (De Clercq et al. 2012; Kalume et al. 2013; Léger et al. 2013; Adakal et al. 2013a).

It should be noted that herders are convinced that heavy tick infestation results in disease and production losses; they are less aware and informed of the fact that low-immunity cattle are more subject to a higher tick burden. This shows the limits of their level of perception in the field of molecular biology, and awareness campaigns on this subject could be useful.

Tick Control

The study shows that stockbreeders use acaricides, but also more traditional methods such as manual tick removal and the use of home-made mixtures. This is also the case in Burkina Faso (Adakal et al. 2013a) and Southern Africa (Moyo and Ferguson 2010; Sungirai et al. 2016). A study in Ivory Coast, although in the same region as Benin, did not report manual tick removal nor the use of home-made mixtures (Madder et al. 2011). Manual tick removal from cattle is a very ancient tradition amongst stockbreeders, but it is difficult to implement with disobedient animals, and is often painful for the cattle, and time consuming. This is in sharp contrast with the use of acaricides which is easy to apply but very expensive, which can be a significant constraint for traditional stockbreeders (Stachurski and Lancelot 2006).

In this study, manual tick removal is still very much used by cattle herders; more than half of them still use it as the main tick control method, making it widespread than any specific acaricides—especially in the north. This is much higher than the figures obtained by Sungirai et al. (2016) in Zimbabwe. In many other regions of the world, manual tick removal is less common, mainly because it is considered to be very tedious (Moyo and Ferguson 2010; Adakal et al. 2013b). We conclude that in Benin, the use of acaricides, although widespread, remains a secondary tick control method. The relatively large group of herders, who are not satisfied with their current tick control method, practise manual tick removal and cannot afford the costs of conventional veterinary treatment. They might be the first in need of new control programs since they face a daily struggle for their livelihood.

Of all products, amitraz-based acaricides are more common than any of the pyrethroids-based products, just as is the case in Zimbabwe (Sungirai et al. 2016). The choice for amitraz should, however, not automatically be attributed to its effectiveness, as the geographic availability may determine the application of acaricides (Adakal et al. 2013b). Overall, all acaricides were considered to be effective by their users. Unfortunately, all interviewed acaricide users in Benin appear to exceed the recommended doses. For alphacypermethrin and cypermethrin, we recorded use of four to five times the required dose, and for amitraz, dosage was six times higher than recommended. In light of the recent proof of acaricide resistance of *R. (B.) microplus* using a larval package test (Adehan et al. 2016a), levels of resistance expressed through resistance ratios RR_{50} varied between 37.7 and 143.34 for deltacypermethrin, between 1.96 and 66.96 for alphacypermethrin and between 4.25 and 78.53 for amitraz. Overall, four strains out of five expressed levels of resistance from moderate to high. Consequently, Beninese cattle herds could be at serious risk of an escalation in tick infestations and tick-borne diseases. Alternative solutions in the fight against tick infestation might arise from ethno-veterinary research on plant extracts (Adehan et al. 2016b), or from adaptive management.

Policy Implementation

The management of control programs and their social context rather than technology appears to be the weak link in effective tick control programs (Pegram et al. 2000; Walker 2011b). Whether the policy objective is to increase rural prosperity, decrease tick burden, limit the spread of *R. microplus* or to avoid the emergence of multi-drug resistant ticks, policy makers base their decisions on studies on national and individual perceptions of the need for tick

control (Pegram et al. 1993). Especially in regions with a high number of smallholders, it can be challenging to implement a consistent control strategy, and owner adherence is paramount for success. Therefore, the proposed control actions need to be in concordance with the daily activities and constraints of the farmers. We have attempted to provide an explorative study of the social context of the cattle herding population in three departments in Benin.

Conclusion

This study investigated the perception of Beninese cattle herders on tick burden and tick control and remains one of the rare studies to report extensively on the perceptions of West African cattle herders. This study indicates that herders have a non-negligible level of skill in tick identification and perception of seasonality of abundance. Moreover, it describes the tick burden they face, even though the agreement between those perceptions and effective tick prevalence merits a deeper investigation. For tick control, a non-negligible part of them still uses manual tick removal, especially in the north of the country, although this method is very strenuous, time consuming and not always effective. The main reason why these herders are not using acaricides is the lack of purchasing power. In the southern region, herders have the financial means to apply acaricides and their users obtain satisfactory results, all the while unaware that they are considerably increasing the risk of emerging tick resistance by applying large overdoses of acaricides. National and regional tick control programs could assist these rural communities in protecting their livelihoods against ticks and tick-borne diseases, but only if they take into account the targeted herders and their perception on cattle management and tick control. Almost certainly, involving the cattle herders represents the first step in monitoring ticks, tick-borne diseases and their impact on animal production.

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