SPECIES DIVERSITY, DISTRIBUTION AND PREDILECTION SITES OF TICKS (ACARINA: IXODIDAE) ON TRADE CATTLE AT ENUGU AND ANAMBRA STATES, SOUTH-EASTERN NIGERIA

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Abstract

Species diversity, distribution and predilection sites of ticks introduced from north-eastern Nigeria into Enugu, Ugwuoba, and Amansea Cattle Markets in south-eastern Nigeria were determined between March 2007 and April 2008. *Amblyomma variegatum*, *Boophilus annulatus, Hyalomma truncatum* and *Rhipicephalus appendiculatus* which have been implicated as vectors of tick-borne infectious diseases (TBID) of man and animals were identified. Percentage composition of the ticks was *Amblyomma variegatum* (20.05%), *Boophilus annulatus* (22.05%), *Hyalomma truncatum* (34.84%) and *Rhipicephalus appendiculatus* (23.06%). The values for Simpson's indices also weighted towards the abundance of the commonest species as *Hyalomma truncatum* (0.1211), *Rhipicephalus appendiculatus* (0.0529), *Boophilus annulatus* (0.0484), and *Amblyomma variegatum* (0.0399). There was no significant differences between ecological indices for the cattle markets studied (p>0.001). Generally, the neck region contributed nearly 13.53% of all ticks recovered, while the hind legs, back, belly, forelegs, head, and tails contributed about 11.53, 10.9, 8.4, 7.02, 6.14 and 5.14% respectively. The flanks, scrotum and dewlap yielded 5.14% each, followed by the udder (4.14%), ears (4.14%), brisket (3.88%), groins (3.88%), shoulders (2.63%), and escutcheon (2.63). Potential risk of TBID outbreak in the study-area and environs is discussed. This result will help to fill the gap in the knowledge of the species diversity, distribution and predilection sites of ticks introduced into the study-area. It may also stimulate further research interest in the ecology of disease vectors as well as provide evidence-based decision for the surveillance of potential TBID transmission in Nigeria.

Keywords: ticks, species diversity, predilection sites, TBID, trade cattle, Nigeria.

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Introduction

Ticks (Phylum: Arthropoda) studied in Family Argasidae and Ixodidae), have been reported to surpass all other arthropods in the number and variety of diseases they transmit to man and animals (Okello-Onen *et al* 1999). Ixodids live on moist and humid environments, where they are external, blood-sucking parasites of humans, pets, livestock, and wild animals (CDC, 2008). Argasids, which are markedly resistant to starvation, can survive for many years without blood meal, and rarely stay on the host but would emerge from the sandy soil to feed voraciously before leaving the host (Furman and Loomis, 1984). Ticks have four developmental forms: an egg stage; a larval stage; a nymphal stage; and female and male adults. Majority of Ixodids are known as "3-host ticks", and in their life cycle, a newly hatched larva feeds on a host, drops off to the ground, and moults to a nymph. A nymph seeks out and feeds on a second host, drops off to the ground, and moults to an adult. Male and female adults seek out a third host, feed, mate, and drop off to the ground. Males die soon thereafter, while females eventually lay eggs on the soil. Depending on the species, a single female may lay 3,000-8,000 eggs and then dies. Since each developmental stage (larva, nymph and adult)

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requires blood meal before moulting (larva and nymph) and for maturation of eggs (adult female), there are ample opportunities for these life stages to bite, and when infected, transmit disease pathogens to their host. Infection in most cases could be transovarial, whereby an infected adult female tick passes the infection to the eggs which hatch into already infected larvae that serve to propagate the infection.

Cattle trading, which increases peoples' exposure to potential tick-bite, is important in the distribution and transmission of tick-borne infectious diseases, TBID (Sumilo *et al* 2006; Taylor *et al* 2001). Tick-bite related-illnesses – African tick-bite fever transmitted by the bite of *A. variegatum* and *A. hebraeum* (Cohen *et al* 2009; Whitman *et al* 2007; Childs and Paddock, 2003; Jensenius *et al* 2003; Mertem and Durden, 2000), Tick-borne Relapsing Fevers transmitted by *Ornithodoros* and *Argas* species (Stanek, 1995), Q-fever and Rickettsiosis transmitted by *Ornithodoros moubata* (Okello-Onen *et al* 1999), Crimean-Congo Hemorrhagic Fever (CCHF) transmitted by several genera of ticks (Hoogstraal, 1979; Swanepoel, 1994; Whitehouse, 2004; Ergonul, 2006), tick fever and tick paralysis associated with *Rhipicephalus* species (Okello-Onen *et al* 1999), and human babesiosis transmitted by *Boophilus* species (Urguhart *et al* 2003) — may pose unidentified human health risks in areas where ticks are not routinely suspected. Because of recurrent febrile symptoms associated with TBID, the condition is often obscured by malaria (Nordstrand *et al* 2006).

Species diversity deals with the total number (N) of species (S) encountered in the sample, expressed as Species Richness ($d = S\text{-}1/In\ N$) *and* Evenness ($E = H\ log\ S$) (Margalef, 1958). Shannon-Wiener Index of Diversity is a measure which combines richness and evenness into a single value $H = (N \log N - \Sigma fi \log fi)/N$ where fi is the abundance and N the total number of individuals in the species, S is the total number of species, and In is the Naperian or natural logarithm (Fisher *et al* 1943). A greater number of species, as well as a more even distribution among species will therefore increase species diversity measured by Shannon-Wiener Index (Lloyd and Ghelardi, 1964). The probability of picking two organisms at random that are different species, known as Simpson's Dominance Index (C), is expressed as $C = \Sigma(Pi)^2$ or $\Sigma(ni/N)^2$, where ni = number of individuals of the *ith* species; N being the total number of individuals for all species; Pi being the proportional abundance of *ith* species i.e., $Pi = ni/N$. Simpson's dominance index is weighted towards the abundance of the commonest species (Fisher, 1943). The formula $\Sigma(ni/N)^2$ refers to a finite population where all of the members have been counted. Since it is impossible to count all members, an unbiased estimator known as Simpson's Index, $D = \Sigma ni\ (ni\text{–}1)/N\ (N\text{–}1)$ has been developed for sampling from infinite natural population (Ogbeibu, 2005).

Movement of cattle into new areas would be the introduction-ticks, thereby increasing the potential risk of TBID in the new area (Ford *et al* 2009; Morens *et al* 2004), and this may also affect the role of wild life in the maintenance of natural *foci* of TBID (Borcie *et al* 1990). Zoologists are therefore required to monitor, particularly, the evolution of traditional ticks' habitats so as to prevent the spread of TBIDs for which they are carriers (Ikpeze *et al* 2007). The aim of this work was to determine the species diversity and distribution of ticks on preferred sites on cattle at cattle markets in Enugu, Ugwuoba, and Amansea, south-eastern Nigeria; emphasizing the potential risk of TBID outbreak in the study-area and environs. This result will help to fill the gap in the knowledge of species diversity, distribution and predilection sites of ticks on trade cattle It may also stimulate further research interests in the ecology of arthropod-borne disease vectors as well as provide evidence-based decision for the surveillance of potential TBID transmission in Nigeria.

Materials and methods

The study used the numbers of species, and individuals of each species of ticks recovered from cattle in cattle markets at Enugu (Latitude 6º 26´N; Longitude 7º 29´E), Ugwuoba (Latitude 6º 16´N, Longitude 7º 11´E), and Amansea (Latitude 6º 13´N, Longitude 7º 05´E), south-eastern Nigeria, to determine species diversity and distribution of the ticks on cattle. The study-area was chosen because cattle purchased and brought from north-eastern Nigeria, especially Gashua (Latitude 12º 44´N; Longitude 7º 05´E), Nguru (Latitude 12º 49´N; Longitude 10º 24´E), and Bauchi (Latitude 10º 18´N; Longitude 9º 50´E) to the study-areas have been reported to be heavily infested with ticks (Dipeolu, 1975), and may therefore increase the potential risks of TBID outbreak in the study-area and environs.

A total of 450 cattle, comprising 150 from each of the cattle market were systematically examined for the presence of ticks between March 2007 and April 2008. No conventional restraint equipments were available at the cattle markets, so, consenting herdsmen superimposed zoo-psychology on the animals and carefully recovered the ticks manually, while the research team observed and recorded the different parts of cattle from where ticks were recovered. Ticks from different predilection sites were placed in separate containers (containing 70% alcohol) already labelled for the purpose. Collections were done between 7-9 am on the appointed days.

Ticks recovered were taken to the laboratory in Department of Parasitology and Entomology, Nnamdi Azikiwe University (UNIZIK) Awka, cleaned and initially sorted according to their external morphological similarity. Representative samples of the ticks were positioned adjacent the meter rule and their images were captured with an 8.2 mega pixel digital camera to reveal their relative sizes in millimeters (Plate 1). The pictures were transferred with Easy-share Software to the computer system. Power Point Tools were thereafter employed to visualize and label key morphological characteristics (Plate 2) used for identification according to Okello-Onen *et al* (1999).

Field data were analyzed quantitatively to determine the species diversity and distribution of ticks over predilection sites on cattle. The Shannon-Wiener Index was employed in the calculation of '*t*' that tested for significant difference in diversity indices between any two of the cattle markets, according to Ogbeibu (2005), using the formulae:

$t = H_1 - H_2/\sqrt{(S^2H_1 + S^2H_2)}$, where S^2H = Variance of $H = \{\Sigma fi \log^2 fi - (\Sigma fi \log fi)^2/N\}/N^2$; df = Degrees of Freedom $= (S^2H_1 + S^2H_2)^2/\ [(S^2H_1)^2/N_1 + (S^2H_2)^2/N_2]$

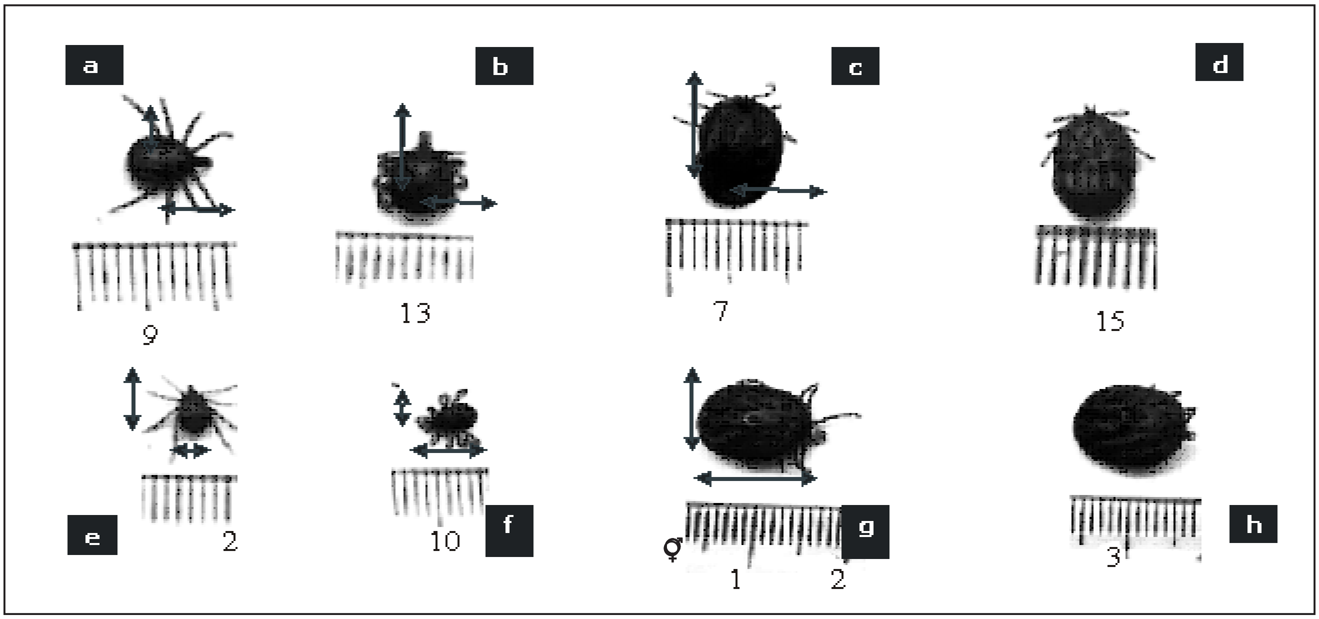

Plate 1: Relative sizes of ticks recovered from cattle under study (Length x Width in mm approx.)
a= ♂ *Amblyomma* dorsal (5 x 4 mm), **b**= *Amblyomma* dorsal (6 x 5 mm); **c**= *Boophilus* dorsal (13 x 6.5 mm), **d**= *Boophilus* ventral, **e**= *Hyalomma* dorsal (4 x 2.5 mm), **f**= *Hyalomma* dorsal (4 x 3 mm);
g= *Rhipicephalus* dorsal (11 x 9 mm), **h**= *Rhipicephalus* ventral.

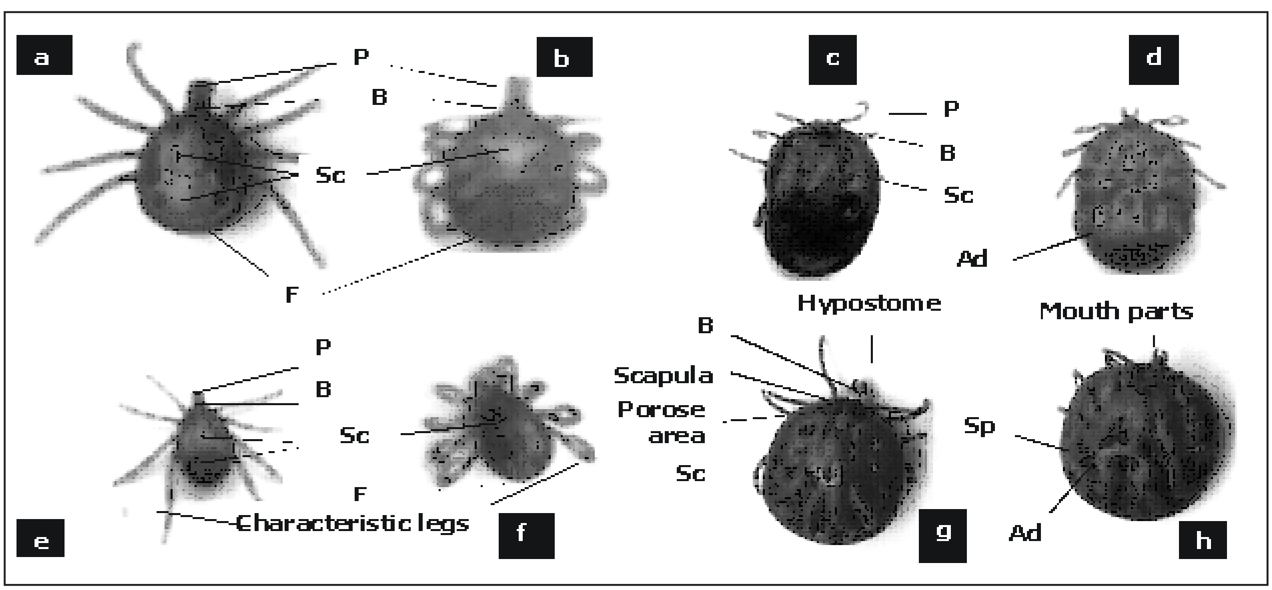

Plate 2: Key Identification features on dorsal and ventral sides of ticks.
a= *Amblyomma* dorsal, **b**= *Amblyomma* dorsal, **c**= *Boophilus* dorsal, **d**= *Boophilus* ventral,
e= *Hyalomma* dorsal, **f**= *Hyalomma* dorsal, **g**= *Rhipicephalus* dorsal, **h**= *Rhipicephalus* ventral.
P = Palps; **B** = Basis capitulum; **Sc** = Scutum; **E** = Eyes; **Ag** = Anal groove;
A = Anal groove; **F** = Festoons; **Sp** = Spiracular plates; **Ad** = Ventral plates (see Table 1 for details).

Results

Plate 1 revealed the relative approximate length and width of engorged adult ticks recovered from cattle in the study as *A. variegatum* dorsal (5 mm Long x 4 mm Wide), *A. variegatum* dorsal (6 x 5 mm), *B. annulatus* dorsal (13 x 6.5 mm), *H. truncatum* dorsal (4 x 2.5 mm), *H. truncatum* dorsal (4 x 3 mm), and *R. appendiculatus* dorsal (11 x 9 mm). Key identification features on dorsal and ventral sides of the ticks included the presence of eyes, shape of palps and basis capitulum, ornamentation of scutum, nature of anal groove, festoons and spiracular plate, presence or absence of ventral plates and as indicated in Table 1 and Plate 2.

Table 1: Key identification features of ticks recovered in the study-area.

Features	***Amblyomma variegatum***	***Boophilus annulatus***	***Hyalomma truncatum***	***Rhipicephalus appendiculatus***
	Present	**Present**	**Present**	**Present**
Eyes Palps (P)	Much longer than wide	Ridged dorsally or laterally	Much longer than wide	Wider than long
Basis capitulum (B)	Rectangular	Hexagonal dorsally	Hexagonal dorsally	Hexagonal Dorsally, with spurs on each side
Scutum (Sc)	Ornamental	Not ornamented	Not ornamented	Not ornamented
Anal groove (A)	Never extending anteriorly around anus	Faint (Obsolete)	Never extending anteriorly around anus	Never extending anteriorly around anus
Festoons (F)	Regular (not coalesced)	Absent	Partially coalesced	Present
Spiracular plate (Sp)	With tail-like protrusion	Round (Oval)	With tail-like protrusion	With bill-like protrusion
Ventral plates (Ad)	Absent	Present ⚥	Present	Present
Legs	–	Normal	Banded	Coxa IV of male normal size

(See Plates 1 and 2 for details).

Percentage composition of ticks recovered in the study area was *H. truncatum* (34.84%), *R. appendiculatus* (23.06%), *B. annulatus* (22.05%), and *A. variegatum* (20.05%) as recorded in Table 2. Values for Simpson's indices weighted towards the abundance of the commonest species *Hyalomma truncatum* (0.1211), *R. appendiculatus* (0.0529), *B. annulatus* (0.0484), and *A. variegatum* (0.0399). The Shannon-Wiener diversity and Simpson's dominance indices computed for the cattle markets under study are also shown in Table 2.

Values derived from data in Table 2 were substituted in the formulae:

$t = H_1 - H_2/v\ (S^2H_1 + S^2H_2)$, where S^2H = Variance of $H = \{\Sigma fi \log^2 fi - (\Sigma fi \log fi)^2/N\}/N^2$; *df* = Degrees of Freedom = $(S^2H_1 + S^2H_2)^2/ [(S^2H_1)^2/N_1 + (S^2H_2)^2/N_2]$ to obtain the variances Var. H_1, Var. H_2, and Var. H_3 for Enugu, Ugwuoba and Amansea Cattle Markets as:

Var. $H_1 = \{272.0129 - (182.1029)^2/122\}/ (122)^2$
$= 0.4663/ (122)^2 = 0.0000313.$

Var. $H_2 = \{1083.1278 - (570.9993)^2/302\}/ (302)^2$
$= 3.5284/ (302)^2 = 0.0000386.$

Var. $H_3 = \{1472.7362 - (741.2102)^2/374\}/ (374)^2$
$= 3.7722/ (374)^2 = 0.0000269.$

For Test of significant difference between diversity in Enugu and Ugwuoba:

$t_{cal} = 0.5944 - 0.5893/ \sqrt{(0.0000313 + 0.0000386)}$
$= 0.5383$

$df = (0.0000313 + 0.0000386)^2/ [(0.0000313)^2/122 + (0.0000386)^2/302] = 3.9974.$

This is equivalent to 8 (infinity) *df*. Critical $t_{0.001, 8} = 3.2905$. t_{cal} $0.5383 < 3.2905$ ($p>0.001$).

For Test of significant difference between diversity in Enugu and Amansea:

$t_{cal} = 0.5944 - 0.5910/ \sqrt{(0.0000313 + 0.0000269)}$
$= 0.4456.$

$df = (0.0000313 + 0.0000269)^2/ [(0.0000313)^2/122 + (0.0000269)^2/374] = 4.2181$

This is equivalent to 8 (infinity) *df*. Critical $t_{0.001, 8} = 3.2905$. t_{cal} $0.4456 < 3.2905$ ($p>0.001$). For Test of significant difference between diversity in Amansea and Ugwuoba:

$t_{cal} = 0.5910 - 0.5893/ (0.0000269 + 0.0000386)$
$= 0.2101.$

$df = (0.0000269 + 0.0000386)^2 / [(0.0000269)^2/374 + (0.0000386)^2/302] = 7.2488$.

This is equivalent to 8 (infinity) *df*. Critical $t_{0.001, 8} = 3.2905$. t_{cal} $0.2101 < 3.2905$ ($p>0.001$).

Therefore, there was no significant difference between diversity indices in the three Cattle Markets studied ($p>0.001$).

Table 3 indicated the distribution of the ticks over predilection sites on cattle under study. Generally, the neck region contributed nearly 13.53% of all ticks recovered from cattle, followed by the hind legs, back, belly, forelegs, head, and tails with about 11.53, 10.9, 8.4, 7.02, 6.14 and 5.14% respectively. The flanks, scrotum and dewlap yielded 5.14% each, while the udder, ears, brisket, groins, shoulders, and escutcheon contributed about 4.14, 4.14, 3.88, 3.88, 2.63, and 2.63%, respectively.

Table 2: Species diversity of ticks recovered in the study-area.

Species (*S*=4)	Number recovered from 150 cattle sampled at each cattle market						Total		
	Enugu		Ugwuoba		Amansea				
	fi	(%)	*fi*	(%)	*fi*	(%)	$N=\Sigma fi$	$Pi=ni/N$	Simpson's index, $ni(ni-1)/N(N-1)$
A. variegatum	23	14.4	60	37.5	77	48.1	160	0.2005	0.0399
B. annulatus	29	16.5	66	37.5	81	46.0	176	0.2205	0.0484
H. truncatum	39	14.0	108	38.8	131	47.1	278	0.3484	0.1211
R. appendiculatus	31	16.8	68	36.9	85	46.2	184	0.2306	0.0529
Σ	122		302		374		798	1	0.2623

Diversity indices	Cattle Markets		
	Enugu	Egwuoba	Amansea
Shannon-Weiner diversity index, $H=(N\log N-\Sigma fi\log fi)/N$	0.5944	0.5893	0.5910
Simpson's index, $D=\Sigma ni\,(ni-1)/N\,(N-1)$	0.2527	0.2633	0.2616

fi = *n* = Abundance of species, $N=\Sigma fi$ = total number of individuals, *Pi* = Proportion of individuals found in the *ith* species.

Table 3: Distribution of ticks over predilection sites on cattle sampled in the study-area.

Predilection sites	*Amblyomma variegatum*	*Boophilus annulatus*	*Hyalomma truncatum*	*Rhipicephalus appendiculatus*	Total	
	n = fi	*n = fi*	*n = fi*	*n = fi*	*N*	% of 798
Head	0	0	0	49	49	6.14
Ears	0	0	0	33	33	4.14
Dewlap	21	7	0	13	41	5.14
Neck	0	90	0	18	108	13.53
Brisket	18	0	0	13	31	3.88
Shoulders	0	14	0	7	21	2.63
Forelegs	29	6	10	11	56	7.02
Back	13	23	45	6	87	10.90
Flanks	0	15	21	5	41	5.14
Belly	23	21	20	3	67	8.40
Tail	0	0	26	20	46	5.76
Escutcheon	0	0	15	6	21	2.63
Groins	0	0	31	0	31	3.88
Scrotum	13	0	28	0	41	5.14
Udder	33	0	0	0	33	4.14
Rear legs	10	0	82	0	92	11.53
Σ	160	176	278	184	ΣΣ=798	100
100 (*Pi*)	20.05	22.05	34.84	23.06		

fi = *n* = Abundance of species, $N=\Sigma fi$ = total number of individuals, *Pi* = Proportion of individuals found in the *ith* species.

Discussion

From Plates 1 and 2, it could be seen that the common genera of ticks being introduced through trade cattle into the study-areas have been identified as *Amblyomma, Boophilus, Hyalomma* and *Rhipicephalus* (Table 1). Simpson's dominant indices indicated that *Hyalomma* was the dominant species but Shanon-Weiner indices confirmed there were no significant differences in between species diversity in the three cattle markets. Interestingly, these four species have been reported to bite humans and vector several protozoa, viral, bacterial and rickettsial diseases of humans and domesticated animals. Dermatosis, inflammation, swelling, ulceration, and itching can result from a tick bite. According to Roberts and Janovy (2000), these reactions often are caused by pieces of mouthparts remaining in the wound after the tick is forcibly removed, but constituents of the ticks' saliva and secondary bacterial infection may also be involved. Tick paralysis is common in humans, dogs, cattle and other animals when they are bitten near the base of the skull. This paralysis seems to result from toxic secretions by the tick and is quickly reversed when the tick is removed (Viljoen, 1986).

Dugbe virus has been isolated from *Hyalomma* (Robers and Janovy, 2000) while African tick-bite fever has been reported from Mali, Niger, Chad and Cameroons which share common borders with northern Nigeria (Mediannikov *et al* 2010; Jensenius *et al* 2003). African tick-bite fever is caused by *Rickettsia africae* and is transmitted by *A. variegatum* and *A. hebraeum* (Cohen *et al* 2009). *A. variegatum* also transmits Crimean-Congo Hemorrhagic Fever virus (CCHFV), *E. ruminantum*, *Theileria* spp., *Anaplasma* spp., and *D. congolensis* (Parola *et al* 2001; Parola *et al* 1999). CCHF is a highly fatal viral disease. In a recent noscomial outbreak of CCHF in Sudan, reverse transcription-PCR identified CCHFV as group III lineage, which indicated links to virus strains from Nigeria (Aradaib *et al* 2010). *Amblyomma* species appears to be a one-host tick, with a one-year life cycle. The larva, nymph and adult are exceptionally worrisome because they will readily bite man (Dipeolu, 1975). There will be a high risk of CCHF if any infected tick is introduced into the study-area. *Boophilus* are one-host ticks.

Because un-engorged specimens are quite small and easily overlooked, *Boophilus* have been exported from endemic zones to new areas (Hoogstraal, 1972). Species of *Boophilus* have been implicated as vectors of CCHF, Gangon viruses as well as Dugbe virus in Nigeria (Roberts and Janovy, 2000). It has been reported that antibodies to *Babesia*, transmitted by *Boophilus* species, have been successfully demonstrated in sera of many healthy individuals in Nigeria (Urguhart *et al* 2003). human babesiosis is an emerging zoonosis, and there is a potential risk of human babesiosis in the study-area. *Rhipicephalus,* whose bites may result in tick paralysis, show little host specificity are both two-host and three-host ticks which could not be overlooked in the study-area.

Another disease vectored by *Rhipicephalus* is theileriosis, caused by *Theileria parva*. Infected ticks transmit the disease only during the life cycle stage following the infected meal; thus larvae acquiring an infection, transmit it when they feed again as nymphs, and nymphs transmit the infection as adults (Roberts and Janovy 2000). *Ornithodoros moubata* complex, which seldom stays on the host and responsible for Q-fever (Okello-Onen *et al* 1999) was not recovered in the area of study, but there has been an outbreak of *Ornithodoros savignyi* in Gashua (from where trade cattle are being continuously conveyed to the study-areas) during which men and cattle were severely attacked (Onyali *et al* 1989). Q-fever is an acute, self-limiting, systemic disease caused by *Rickettsia Coxiella burneti* and spreads rapidly in cows, sheep, and goats. Infected animal sheds the *Rickettsia* in milk, excreta, placentae and birth fluids. Contamination of the environment leads to airborne dissemination of the *Rickettsia* and predisposes persons in close contact with livestock and other infected materials to infection (*Encyclopaedia Britannica, 2009*). There is therefore a high risk of Q-fever from environmental contamination with infective agents from any infected cattle introduced into the study-area.

Cross-border activity between trans-human pastoralists from Sudan-Sahel region and northern Nigeria may be a major factor in the epidemiology of TBID (Jaenson *et al* 1994), thus increasing the potential risk of TBID outbreak in the study-area through cattle trade. It was also observed that cattle, as soon as they were off-loaded at the cattle markets, were usually taken by herdsmen for grazing and watering before being brought back to the markets for sale. This practice continued until the animals were sold off. Local cattle dealers who bought the animals also trekked the animals, on daily basis, to various lairages in the States before slaughter for sale to the public. During movements of cattle, any engorged larva, nymph and adult female would drop off to continue with the next developmental stage of its life cycle. Ticks are therefore continuously being seeded in the environment, increasing their opportunity to bite man, with potential for TBID transmission in the study areas and environs.

Different preferred or predilection sites of ticks on cattle (Table 3) may be due to parasites' intrinsic behaviours. *Amblyomma* and *Hyalomma* that do not climb on vegetation, run after the stationary host when activated by the host's presence (Okello-Onen *et al* 1999; Mann, 1915). While the animals are lying on their sides, *Hyalomma* may have the opportunity to attach to the tail, escutcheon, around the anus, groin, udder and scrotum. *Amblyomma* would also attach to the belly, udder, scrotum, dewlap, brisket and flanks as observed in this study. In these locations, it would also be very difficult for the host to dislodge the ticks. *Boophilus* and *Rhipicephalus* species climb onto vegetation and quest before attaching to their hosts (Okello-Onen *et al* 1999). It was observed that *Boophilus* which preferred the sides, shoulders, neck and dewlap of cattle, and *Rhipicephalus* (brown ear tick) that preferred the head and peri-anal regions, especially the ears and tail switch) could easily access these predilection sites while questing on tall grasses and vegetation, as the animals pass by.

Occupation of the different predilection sites by ticks may involve complex intrinsic behaviours that are under chemical control. Roberts and Janovy (2000) had explained that different pheromones which emanate from the anus, coxal glands, and female genital aperture of female ticks control other behaviours such as aggregation, searching and aggregation, clasping and attachment during mating, attraction and potential mate recognition in males, mounting and copulation. It was observed that most of the male and female adult *A. variegatum* recovered during the study were aggregated in clusters. Generally, the neck region contributed nearly 13.53% of all ticks recovered, while the hind legs, back, belly, forelegs, head, and tails contributed about 11.53, 10.9, 8.4, 7.02, 6.14 and 5.14% respectively. The flanks, scrotum and dewlap yielded 5.14% each, followed by the udder (4.14%), ears (4.14%), brisket (3.88%), groins (3.88%), shoulders (2.63%), and escutcheon (2.63). Perhaps due to the presence of dense hairs, more numbers of ticks were recovered from the neck, limbs, back and belly than from the other parts of the body which had scanty hairs. Nevertheless, the predilection sites recorded in this study were similar to, and confirmed the report of other investigators (Okello-Onen *et al* 1999).

Conclusion

Cattle in the study-area were purchased from north-eastern Nigeria, an indication that the species of ticks found in the north may be introduced into the cattle markets and environs in the south of the country. It is suspected that cattle already grazed in the Sudan-Sahel region got into northern Nigeria, and where among those being sold as trade cattle in the country. Many TBID have been reported from Sudan-Sahel region where these cattle were thought to have grazed. Different developmental stages of the ticks would drop off infested cattle to contaminate the environment; if infected, these ticks will propagate the infection in areas in which they were introduced. It is therefore necessary to initiate and institute the surveillance of TBID to prevent potential outbreak of TBID, especially the study-area and environs, where trade cattle have been shown to introduce potentially infected ticks which can readily bite man and other animals to cause outbreak or emergence of TBID.

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