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# An updated list of the ticks of Ghana and an assessment of the distribution of the ticks of Ghanaian wild mammals in different vegetation zones

**Y. Ntiamoa-Baidu[1*], C. Carr-Saunders[2], B.E. Matthews[2], P.M. Preston[2] and A.R. Walker [3]**

[1]Zoology Department, University of Ghana, Legon, Accra, Ghana: [2]Institute for Cell, Animal and Population Biology, School of Biological Sciences, University of Edinburgh, King's Buildings, West Mains Road, Edinburgh, EH9 3JT, Scotland: [3]Department of Tropical Animal Health, Royal (Dick) School of Veterinary Studies, University of Edinburgh, Roslin, EH25 9RG, Scotland

**Abstract**

Twenty one species of ticks belonging to five genera of the family Ixodidae (Order Acari, sub-order Ixodida) – *Amblyomma, Haemaphysalis, Hyalomma, Ixodes* and *Rhipicephalus* (including the sub-genus *Rhipicephalus (Boophilus)*) – were collected from 1260 mammals, representing 29 species, 14 families and 6 orders, in four vegetation zones in Ghana during the period 1971–1978. Four other species were collected from humans in 1977. In all, eight species appeared to be new records for Ghana: *Amblyomma tholloni* Neumann; *Dermacentor circumguttatus* Neumann; *Haemaphysalis houyi* Nuttall & Warburton; *Ixodes loveridgei* Arthur; *Ixodes oldi* Nuttall; *Ixodes vanidicus* Schultze; *Rhipicephalus complanatus* Neumann; *Rhipicephalus cuspidatus* Neumann. The updated list of tick species in Ghana given here includes 41 species of ixodid ticks and four species of argasid ticks. Most species have been found in neighbouring regions of West Africa but 56 of the 121 different combinations of ixodid tick species and host species found in the collection described here have not apparently been reported before. The new combinations recorded here bring the total number of different combinations of ixodid tick species and mammalian host species now reported in Ghana to 151. The tick species found on wild mammals in Ghana mostly differed from those reported from domestic stock by other authors. The data showed that different tick species occurred in different vegetation zones and that most species displayed a pronounced preference for certain groups of related host species. Some tick species were found in the savanna feeding mainly on large bovids and/or suids; others were found in forests feeding mainly on small bovids, large rodents or small carnivores.

*Present address: World Wide Fund for Nature, Avenue du Mont-Blanc, 1196 CH Gland, Switzerland
Fax: 0041 22 364 4238
E-mail: YNtiamoa@wwfint.org

## Introduction

Ticks (Acari: Argasidae and Ixodidae ) are important to the health of humans and livestock in Ghana as vectors of pathogens and facilitators of disease (Walker & Koney, 1999), as they are in all tropical countries (Hoogstraal, 1981; Pegram & Walker, 1988; Sonenshine, 1993; Jongejan & Uilenberg, 1994). Unfortunately, except for a recent study on the ticks of domestic stock (Walker & Koney, 1999), taxonomically reliable information on ticks in Ghana is very sparse. This paper uses the data from an extensive collection of ticks from wild mammals to create an updated list of the ticks of Ghana and to examine the distribution of the ticks of Ghanaian wild mammals in different vegetation zones. The tick names used here are those given in the new list of valid tick names (Horak *et al*., 2002); their authorities were also derived from that paper.

The first ixodid ticks reported from Ghana were *Amblyomma splendidum* Giebel, *Amblyomma variegatum* (Fabricius), *Haemaphysalis aciculifer* Warburton and *Haemaphysalis parmata* Neumann described by Simpson (1914, 1918), *Haemaphysalis hoodi* Warburton & Nuttall collected by Palmer in 1911 and described by Nuttall & Warburton (1915), *Amblyomma nuttalli* Donitz collected by Macfie in 1914 and cited by Robinson (1926), and *Amblyomma* (previously *Aponomma*) *latum* Koch (Corson, 1916, cited by Hoogstraal, 1956). The first argasids were *Carios* (previously *Argas) vespertilionis* Latreille (Simpson, 1914) and *Argas persicus* (Oken) (Fulton, 1929; Stewart, 1933, 1934). These records plus those of other tick species that are now, as described below, of doubtful taxonomic status (Simpson, 1914, 1918; Corson, 1916 cited by Hoogstraal, 1956; Beal, 1921; Moody, 1922; Fulton, 1929; Stewart, 1933, 1934), provided evidence for the presence in Ghana of seven genera of tick species – *Amblyomma, Haemaphysalis*, *Hyalomma*, *Ixodes* and *Rhipicephalus* (family Ixodidae) and *Argas* and *Carios* (family Argasidae) (Nuttall & Warburton, 1915; Robinson, 1926; Hoogstraal, 1956; Morel, 1958).

Recent taxonomic reappraisals have cast severe doubt on the specific identities of many of the early records. Camicas *et al*. (1998) indicated that the early records of *Haemaphysalis leachi* (Audouin) (Nuttall & Warburton, 1915; Simpson, 1914; Beal, 1921; Moody, 1922) might best be regarded as members of the *Hae. leachi* group. The specific identity of *Boophilus* spp. (Simpson, 1914, 1918; Macfie, 1915; Moody, 1922) and *Hyalomma* spp. (Simpson, 1918; Macfie, 1915; Moody, 1922) are also unreliable. The identity of the very first record of an *Ixodes* species, namely *Ixodes rasus* Neumann, collected by Graham, 1908 (Nuttall & Warburton, 1911), is also unclear (Arthur, 1965); other records of *Ixodes* spp. in Ghana prior to 1970 are rare. Recent studies on the *sanguineus* and *simus* groups of *Rhipicephalus* (Pegram *et al*., 1987a,b,c; Pegram & Walker, 1988) cast doubt on the following records: *Rhipicephalus evertsi evertsi* Neumann (Stewart, 1933); *Rhipicephalus senegalensis* Koch as *Rhipicephalus simus* Koch (Simpson, 1914; Zumpt, 1943); *Rhipicephalus sanguineus* (Latreille) (Simpson, 1914, 1918; Macfie, 1915; Beal, 1921; Stewart, 1933; Findlay & Archer, 1948); *Rhipicephalus tricuspis* Donitz (now *Rhipicephalus lunulatus* Neumann in Ghana) (Stewart, 1935); *Rhipicephalus ziemanni* Neumann (Neumann cited by Morel, 1958).

Between 1935 and the 1970s, when the ticks described in this paper were collected, very little additional information on the tick fauna of Ghana appeared. *Amblyomma* (previously *Aponomma*) *exornatum* Koch, *Argas reflexus* (Fabricius) and *Ornithodoros moubata* (Murray) were identified in the British (Natural History) Museum collections from Ghana (Hoogstraal, 1954, cited in Hoogstraal, 1956). Theiler (1962) reported *Hyalomma truncatum* Koch and *Ixodes cumulatimpunctatus* Schulze. In 1967, Agyen-Frempong reported *Am. exornatum*, *Am. latum* (as *Aponomma leave* Neumann), *Amblyomma nuttalli* Donitz and *Hyalomma aegyptium* (Linnaeus) on reptiles, *Ar. persicus* on poultry and *Am. nuttalli*, *Am. variegatum*, *Hyalomma impressum* Koch, *R. evertsi, Rhipicephalus longus* Neumann (as *Rhipicephalus falcatus* Neumann), *R. lunulatus, R. sanguineus* and *R. simus* on mammals. The recent taxonomic revisions have made the identity of a number of these ticks, in particular the rhipicephalids, uncertain. It appears therefore that the identity of only a few, very distinctive, members of the family Ixodidae (e.g. *Am. nuttalli, Am. variegatum, Am. splendidum, Hae. aciculifer, Hae. hoodi, Hae. parmata)* and the four species belonging to the family Argasidae mentioned above (i.e. *Ar. persicus*, *Ar. reflexus*, *C. vespertilionis* and *O. moubata*) can be accepted as taxonomically correct out of the twenty species reported in Ghana prior to the 1970s. More recently in 1985, Keirans published the Nuttall catalogue, which contained some previously unpublished records. Walker *et al*. (2000) noted the presence of *R. evertsi evertsi*, *R. senegalensis, Rhipicephalus sulcatus* Neumann and *R. ziemanni* in Ghana.

The ticks described here were collected from a wide range of wild mammals in Ghana in the 1970s. While the ticks collected from the grasscutter, *Thryonomys swinderianus* Temminck (Thryonomyidae), which was the subject of a domestication project in Ghana, have already been described by Campbell *et al*. (1978) and Ntiamoa-Baidu (1980, 1986, 1987a,b), this paper is the first description of the ticks found on the other species of wild mammals. The collection was made from animals brought to bushmeat market centres in four different areas of Ghana or trapped in the Mole National Park; a further four species were collected from humans in the Bia National Park. The collection areas represented almost all the different natural vegetation zones found in Ghana, as described by Lane (1962). The collection not only presented an opportunity to create an updated list of the tick species of Ghana and to examine the distribution of the ticks of wild mammals in different vegetation zones, but also enabled an assessment of the extent to which the tick species found on wild mammals overlap with those infesting domestic ungulates (Walker & Koney, 1999) and of the risks of wild animals acting as maintenance hosts for ticks and/or as reservoirs for tick-borne pathogens of domestic stock.

## Materials and methods

### *Climate and ecological zones of Ghana*

Ghana is a coastal West African country facing the Gulf of Guinea and lying within 1°N to 11°N of the Equator. It is bisected by the Greenwich meridian. The climate as described by Wills (1962) and the vegetation as described by Lane (1962), Hall & Swaine (1981) and Sayer *et al*. (1992) are summarized in fig. 1. The mean annual temperature varies between 22°C and 33°C, with an equatorial seasonal variation. Rainfall increases from north to south. However, the south-eastern coastal plain, anomalously, is drier to the south of the 1000 mm isohyet (fig. 1). The altitude of most

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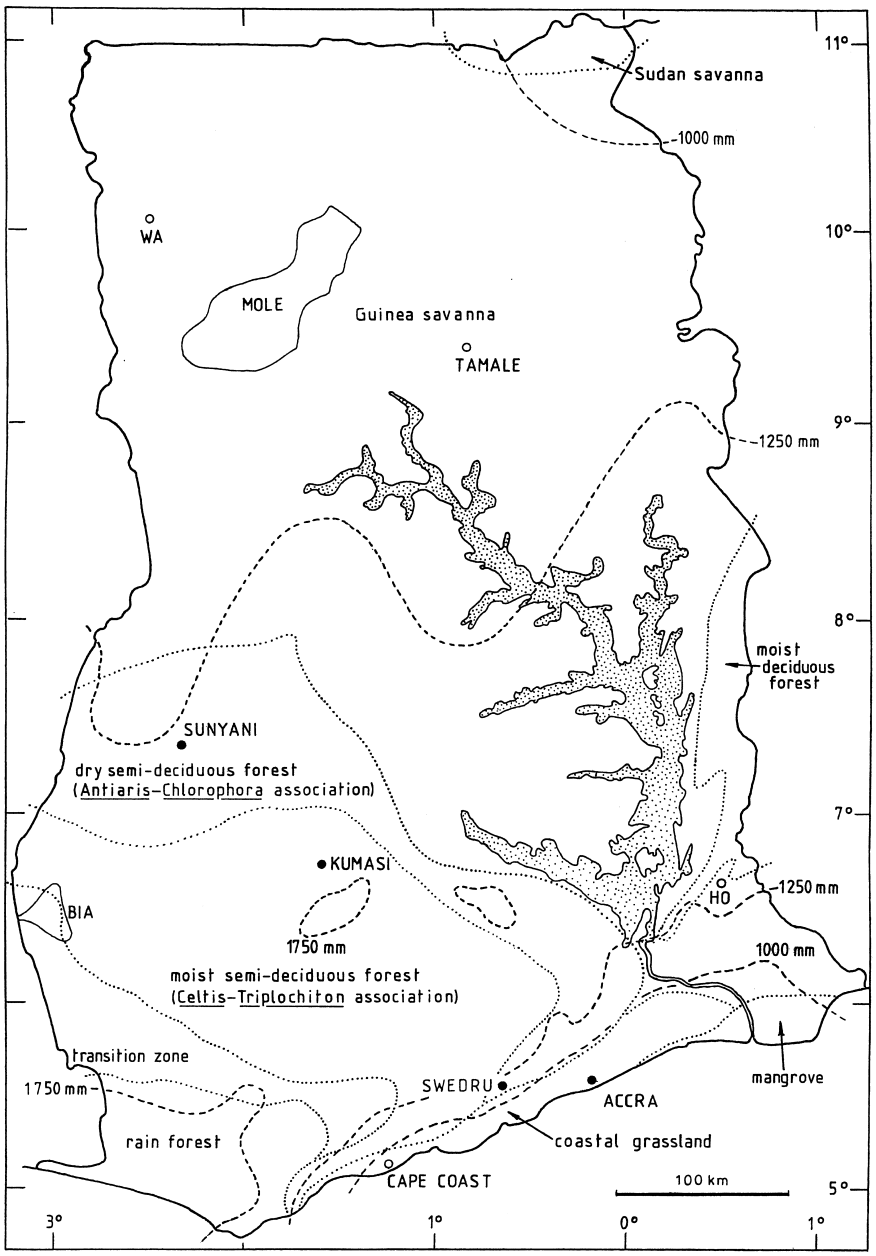


Fig. 1. Map of Ghana showing tick collection points, climate and vegetation zones. Solid circles show the locations of the four bushmeat markets (Sunyani, Kumasi, Accra, Swedru); thin lines indicate the two National Parks (Mole, Bia). Other towns are marked with open circles. Dotted lines show the approximate boundaries of the vegetation zones; dashed lines indicate isohyets. Lake Volta is shown stippled.

of the landmass is between 100 m and 600 m. Zones of differing vegetation type lie between the Sahara Desert and the Gulf of Guinea (Lane, 1962) in bands approximately parallel to the coast, corresponding to the climatic gradient which runs in the same direction (Wills, 1962) (fig. 1). These vegetation zones are fairly distinct (fig. 1) but transition areas of varying size occur around their borders. The northern half of Ghana is tropical savanna with tropical forest occurring in the south of the country. Evergreen forest and semi-deciduous forest occur in the south-west (Hall & Swaine, 1981). The coastal plain is mainly coastal thicket; a small area in the south-eastern coastal plain is tropical steppe. More recent publications confirm the existence of the vegetation zones described by Lane (1962) and show the current, reduced extent of the forest areas (Sayer *et al.*, 1992).

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*Tick collection sites, sampling of hosts for ticks and identification of ticks and hosts*

The six tick collection sites (fig. 1) differed in terms of vegetation, as described by Lane (1962) and Hall & Swaine (1981), and climate (Wills, 1962).

**1.** Mole National Park, Northern Region, lies in the Guinea savanna woodland, which consists of a continuous cover of tall perennial grasses and a few fire resistant broad-leaved trees. During the rainy season, the medium sized trees form an almost complete canopy. There is a single rainy season, with rainfall peaking in August/September, and an exceptionally long dry season from November to February, when the relative humidity is very low. The mean annual rainfall is 1125 mm. Ticks were collected intermittently from 1971 to 1974, as and when the opportunity arose during other field operations.
**2.** The Sunyani bushmeat market, As Usual Chop Bar, Brong-Afaho Region, was supplied with animals hunted in the *Antiaris–Chlorophora* association. This forest is more exposed to the drying winds (the harmattan) from the north than the *Celtis–Triplochiton* association and is therefore classified as 'dry' semi-deciduous forest (Hall & Swaine, 1981). The upper storey is broken and lower canopies merge to become almost continuous. There are two rainy seasons: maximum rainfall being in May to June and September to October. December to February and July to August are much drier; the mean annual rainfall is 1115 mm. Ticks were collected at regular intervals from January 1976 to November 1978.
**3.** The Atwemonom bushmeat market at Kumasi, Ashanti Region, was mainly supplied with animals hunted in the *Celtis–Triplochiton* Association ('moist' semi-deciduous forest) but some animals were trapped further north in the transition area toward Guinea savanna woodland. The *Celtis–Triplochiton* association is, in its natural state, a two-level forest: the upper storey is deciduous with leaf cover being lost for varying periods between October and April; the lower storey is evergreen. Most farming occurs within this association and scattered large trees commonly stand over farms or fallow areas. Rainfall patterns are very similar to those of Sunyani. The mean annual rainfall is 1273 mm. Ticks were collected at regular intervals from June 1975 to January 1978.
**4.** The Mankesim bushmeat market, Central Region, received animals from Swedru and its surrounding villages. These animals were mainly hunted in the transition zone between coastal thicket and *Antiaris–Chlorophora* association, semi-deciduous forest. There are two main rainy seasons: the principal one reaches its maximum in May/June; the subsidiary occurs in October. The mean annual rainfall is 1147 mm. Ticks were collected on a regular basis from February 1976 to April 1977.
**5.** The Kantamanto bushmeat market in the capital city of Accra received animals from a wide area of the coastal zone. The vegetation of the coastal thicket and grassland consists of a dense scrub tangle about 5 m in height with relatively few trees. The thicket decreases and the grassland increases from north-east to south-west within this area. Ticks were collected from February to July 1976.
**6.** The Bia National Park lies to the west of Kumasi within the moist semi-deciduous forest (*Celtis–Triplochiton* association) and the moist evergreen forest zones. Ticks were collected from humans (game rangers) over three days in October 1977.

With the exception of certain small mammals, such as mice and shrews, the bushmeat trade (Asibey, 1974; Adeola, 1992; Sayer *et al*., 1992; Ntiamoa-Baidu, 1997) in Ghana provided the opportunity to examine almost all the species of wild animals living in the semi-deciduous forest and coastal regions (appendix 1) for external parasites. All the animals described here had been caught by groups of, or solitary, hunters specifically to sell in bushmeat markets and none were especially obtained for the study. The taxonomic designation of the mammals employed here is as described by Kingdon (2001); the taxonomic authorities for their scientific names were obtained from Wilson & Reeder (1993).

Ticks were obtained from bushmeat markets by sampling animals prior to their being sold. A few animals from Swedru and the Kantamanto bushmeat market were sealed individually in polythene bags to ensure the retrieval of detached external parasites, and animals transported to the laboratory in Ghana prior to removal of the ticks (Ntiamoa-Baidu, 1980). In general the animals were examined by raising the hairs progressively for a full body search. All parasites from one host were preserved together in 70% ethanol and data on the locality and date of collection, the type of host, the host sex, and an accession number relating to the host were recorded. At the University of Edinburgh, the senior author (YN-B) and the late J.A. Campbell identified the ticks. Ticks whose taxonomic status has been changed since the original identifications were made, e.g. *Amblyomma cuneatum* (Macalister), *R. tricuspis, R. sulcatus* and members of the *Hae. leachi* group, were examined and their identities confirmed by ARW.

*Assessment of the tick species in the collection: their number, hosts, zonation and tick-host combinations*

The database for this collection was made using Microsoft Access 97 software so that the tick records could be analysed both qualitatively and quantitatively. The ticks were recorded using the names originally used. A very few species are described here using the more recent synonyms: *Am. cuneatum* has been superseded by *Amblyomma compressum* (Macalister); *R. tricuspis* in Ghana by *R. lunulatus*; *Hae. leachi* is used to indicate any member of the *Hae. leachi* group (Camicas *et al*., 1998). *Boophilus geigyi* (Aeschlimann & Morel) is designated as *Rhipicephalus (Boophilus) geigyi* as described by Horak *et al*. (2002). The tick species and host species recorded from the different vegetation zones, the number of records of each species of adult tick on a given host species and the number of records of immature ticks of a given genus on a given host species were deduced by querying the database. It should be noted that the number of records refers throughout to the number of individual mammal hosts from which a given tick species was collected and not to the number of ticks collected from individual hosts.

An updated list of all the ticks belonging to the families Argasidae and Ixodidae reported from Ghana to date was compiled (table 1) to show the original record of that tick species in Ghana and the confirmatory records checked against current taxonomic understanding. This table comprises reports of other authors, including the seven tick species newly described on domestic stock (Walker & Koney, 1999), the new and confirmatory records made by Campbell *et al*. (1978) and Ntiamoa-Baidu (1980), and the findings of

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Table 1. The 45 tick species reported from Ghana to date.

Family Argasidae (3 genera, 4 species)
*Argas reflexus* (Fabricius): Hoogstraal (1954) cited by Hoogstraal (1956) [1] (only report)
*Argas persicus* (Oken): Fulton (1929) [1]; Agyen-Frempong (1967) [2]
*Carios* (previously *Argas) vespertilionis* Latreille: Simpson (1914) [1] (only report)
*Ornithodoros moubata* (Murray): Hoogstraal (1954) cited by Hoogstraal (1956) [1] (only report)

Family Ixodidae (6 genera, 41 species)
*Amblyomma compressum* (Macalister): Ntiamoa-Baidu (1980) [1]; this paper (32) [2]
*Amblyomma* (previously *Aponomma*) *exornatum* Koch: Hoogstraal (1954) cited by Hoogstraal (1956) [1]; Agyen-Frempong (1967) [2]
*Amblyomma* (previously *Aponomma*) *latum* Koch: Corson (1916) cited by Hoogstraal (1956) [1]; Agyen-Frempong (1967) (as *Aponomma leavei)* [2]
*Amblyomma nuttalli* Donitz: coll. Macfie in 1914 (Robinson, 1926) [1]; Ntiamoa-Baidu (1980) [2]
*Amblyomma paulopunctatum* Neumann: Ntiamoa-Baidu (1980) [1] (only report)
*Amblyomma splendidum* Giebel: Simpson (1914) [1] (only report)
*Amblyomma tholloni* Neumann: this paper (3) [1] (only report)
*Amblyomma variegatum* (Fabricius): Simpson (1914, 1918) [1]; Walker & Koney (1999) [2]
*Dermacentor circumguttatus* Neumann: this paper (3)[1] (only report)
*Haemaphysalis aciculifer* Warburton: Simpson (1914) [1]; this paper (5) [2]
*Haemaphysalis hoodi* Warburton & Nuttall: coll. Palmer in 1911 (Nuttall & Warburton, 1915)[1] (only report)
*Haemaphysalis houyi* Nuttall & Warburton: this paper (3)[1] (only report.)
*Haemaphysalis leachi* group: *Haemaphysalis leachi* (Audouin) (syn. *H. leachii*; *Hae. leachi leachi*): coll. Palmer in 1911 (Nuttall & Warburton, 1915) [1]; this paper (45) [2]
*Haemaphysalis leachi* group: *Haemaphysalis spinulosa* Neumann: Walker & Koney (1999) [1] (only report)
*Haemaphysalis parmata* Neumann: coll. Graham in 1908 (Nuttall & Warburton, 1915) [1]; Campbell *et al*. (1978) [2]
*Hyalomma aegyptium* (Linnaeus): Agyen-Frempong 1967 [1] (only report)
*Hyalomma impressum* Koch: Agyen-Frempong 1967 [1]; Campbell *et al*. (1978) [2]; Walker & Koney (1999) [3]
*Hyalomma marginatum rufipes* Koch: Walker & Koney (1999) [1] (only report)
*Hyalomma truncatum* Koch: Theiler (1962) [1]; Walker & Koney (1999) [2]
*Ixodes aulacodi* Arthur: Campbell *et al*. (1978) [1] ; this paper (85) [2]
*Ixodes cumulatimpunctatus* Schulze: Theiler (1962) [1]; Ntiamoa-Baidu (1980) [2]
*Ixodes loveridgei* Arthur: this paper (1) [1] (only report)
*Ixodes moreli* Arthur: Campbell *et al*. (1978) [1] ; this paper (135)[2]
*Ixodes muniensis* Arthur & Burrow: Campbell *et al*. (1978) [1] ; this paper (279) [2]
*Ixodes oldi* Nuttall: this paper: (12) [1] (only report)
*Ixodes rasus* Neumann: Nuttall and Warburton (1911); Ntiamoa-Baidu (1980) [1]; this paper (3) [2]
*Ixodes vanidicus* Schulze: this paper (1) [1] (only report)
*Rhipicephalus (Boophilus) annulatus* (Say): Walker & Koney (1999) [1] (only report)
*Rhipicephalus (Boophilus) decoloratus* (Koch): Walker & Koney (1999) [1] (only report)
*Rhipicephalus (Boophilus) geigyi* (Aeschlimann & Morel): Walker & Koney (1999) [1]; this paper (1) [2]
*Rhiphicephalus complanatus* Neumann: this paper (4) [1] (only report)
*Rhipicephalus cuspidatus* Neumann: this paper (10) [1] (only report)
*Rhipicephalus evertsi evertsi* Neumann: Stewart (1933) [1]; Walker & Koney (1999) [2]
*Rhipicephalus lunulatus* Neumann: Stewart (1925) as *R. tricuspis*[1]; this paper (11) [2]
*Rhipicephalus longus* Neumann: Agyen-Frempong (1967) as *R. falcatus* [1] (only report)
*Rhipicephalus sanguineus* group between *R. sulcatus* Neumann and *R. turanicus* Pomerantzev: Walker & Koney (1999) [1] (only report)
*Rhipicephalus sanguineus* (Latreille): Macfie (1915) [1]; Walker & Koney (1999) [2]
*Rhipicephalus senegalensis* Koch: Simpson (1914) as *R. simus* [1]; this paper (49) [2]
*Rhipicephalus simpsoni* Nuttall: Campbell *et al*. (1978) [1] ; this paper (118) [2]
*Rhipicephalus sulcatus* Neumann: this paper (22) [1] (only report)
*Rhipicephalus ziemanni* Neumann: Neumann cited in Morel (1958) [1]; Ntiamoa-Baidu (1980) [2]

A tick's specific name is followed by the taxonomic authority, the author of the first record [1], then the author(s) of any confirmatory report(s) that may be taken to be taxonomically valid [2,3]. If the species' presence is described for the first time or its presence confirmed by this paper, this is denoted by 'this paper' and the number of records (). Coll: collector. The taxonomy of the ticks and authorities is based on the latest list of valid tick names (Horak *et al*., 2002). The major changes are that *Argas vespertilionis* has been transferred to the genus *Carios; Aponomma exornatum* and *Aponomma latum* have been transferred to the genus *Amblyomma*; the genus *Boophilus* has become a sub-genus of the genus *Rhipicephalus.*

this study. Tick names and taxonomic authorities in the list are based on Camicas *et al*. (1998) and Horak *et al*. (2002).

The results of the surveys at the five individual collection points (Mole, Sunyani, Kumasi, Swedru, Kantamanto) in the different vegetation zones are summarized as tables 2–6. These tables include: the number of records of adult ticks of a given species and the number of hosts of a given species from which that tick species was recorded; the number of records of immature ticks of a given genus and the number of hosts of a given species from which that tick genus was recorded.

The frequency of the adults of the different tick species recorded at the different collection points (table 7) was calculated as follows:

$$\frac{\text{Number of records of adult ticks of a given species from a particular collection point}}{\text{Total number of records of adult ticks of that species from all collection points.}} \times 100$$

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Table 2. Results of surveys in the Mole National Park, Northern Region, Ghana: number of individuals of a host species infested with adult ticks of a particular species or immature ticks (nymphs and/or larvae) of a particular tick genus.

| | | Host species | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ungulates (Artiodactyls) | | | | | | | | | | | | | | |
| | | Bovids | | | | | Suids | | Lags | Rodents | | Carnivores | | | | Primates |
| | | KGI (22) | Kob (7) | WB (6) | BB (1) | RB (1) | WH (12) | RRH (2) | TH (9) | GR (1) | CP (1) | MM (1) | WTM (1) | LPD (1) | JKL (1) | GM (2) |
| Adult ticks | | | | | | | | | | | | | | | | |
| *Rhipicephalus sulcatus* | [22] | 8 | – | – | – | – | 2 | – | 7 | – | – | 1 | – | 1 | 1 | 2 |
| *Amblyomma variegatum* | [12] | 6 | 1 | 1 | 1 | – | 2 | – | – | – | – | – | – | – | 1 | – |
| *R. lunulatus* | [9] | 4 | 2 | 2 | 1 | – | – | – | – | – | – | – | – | – | – | – |
| *R. senegalensis* | [7] | – | 2 | – | – | – | 4 | – | – | – | – | – | – | 1 | – | – |
| *R. cuspidatus* | [8] | – | – | – | – | – | 6 | 2 | – | – | – | – | – | – | – | – |
| *Haemaphysalis aciculifer* | [4] | 1 | 3 | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *R. simpsoni* | [3] | – | 1 | – | – | – | – | – | – | – | 1 | – | – | 1 | – | – |
| *R. (Boophilus) geigyi* | [1] | 1 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Hyalomma truncatum* | [1] | – | – | – | – | – | 1 | – | – | – | – | – | – | – | – | – |
| *Hae. parmata* | [1] | – | – | – | – | – | – | – | – | – | – | – | 1 | – | – | – |
| | | {20} | {9} | {3} | {2} | {0} | {15} | {2} | {7} | {0} | {1} | {1} | {1} | {3} | {2} | {2} |
| Immature ticks | | | | | | | | | | | | | | | | |
| *Amblyomma* sp. | [29] | 14 | 1 | 3 | – | 1 | 4 | 1 | – | – | 1 | 1 | 2 | – | – | 1 |
| *Rhipicephalus* sp. | [7] | – | – | – | – | – | 1 | 1 | 3 | 2 | – | – | – | – | – | – |
| | | {14} | {1} | {3} | {0} | {1} | {5} | {2} | {3} | {2} | {1} | {1} | {2} | {0} | {0} | {1} |

68 records of adult ticks and 36 records of immature ticks were made from a total of 68 mammals between July 1971 and June 1974. ( ) total number of hosts of a given species; [ ] total number of records of a given tick species or genus; { } total number of records from a given host species.
BB, bushbuck; CP, crested porcupine; GM, green monkey, GR, giant pouched rat; JKL, jackal, KGI, kongoni; Lags, lagomorphs; LPD, leopard; MM, marsh mongoose; RB, reedbuck; RRH, red river hog; TH, Togo hare; WB, waterbuck; WH, warthog; WTM, white-tailed mongoose.

Table 3. Results of surveys at the Sunyani bushmeat market, Brong-Afaho Region, Ghana: number of individuals of a host species infested with adult ticks of a particular species or immature ticks (nymphs and/or larvae) of a particular tick genus.

| | | Host species | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ungulates (Artiodactyls) | | | | | | | | | | | |
| | | Bovids | | | | | | Suids | Lags | Rodents | | Carnivores | Pholidotes |
| | | BB (332) | RA (18) | MD (88) | BYD (30) | BLD (22) | RFD (13) | RRH (1) | TH (1) | GR (6) | BTP (18) | CIV (24) | Pangolin (3) |
| Adult ticks | | | | | | | | | | | | | |
| *Haemaphysalis parmata* | [448] | 318 | 11 | 67 | 23 | 17 | 10 | – | – | 1 | 1 | – | – |
| *Ixodes muniensis* | [223] | 156 | 2 | 26 | 23 | 10 | 4 | – | – | – | – | 2 | – |
| *Rhipicephalus ziemanni* | [134] | 116 | 1 | 4 | 4 | 2 | 2 | 1 | – | – | – | 4 | – |
| *I. moreli* | [55] | 26 | – | 11 | 8 | 7 | 3 | – | – | – | – | – | – |
| *I. cumulatimpunctatus* | [43] | 15 | – | 3 | 15 | – | – | 1 | – | 5 | – | 4 | – |
| *Hae. leachi* | [24] | – | – | – | 1 | – | – | – | – | – | – | 23 | – |
| *I. oldi* | [11] | – | – | – | – | – | – | – | – | – | – | 11 | – |
| *I. aulacodi* | [8] | 4 | – | 2 | – | 1 | – | – | – | – | – | 1 | – |
| *R. simpsoni* | [7] | 3 | 1 | 1 | – | – | 1 | – | – | – | – | 1 | – |
| *Amblyomma compressum* | [3] | – | – | – | – | – | – | – | – | – | – | – | 3 |
| *I. rasus* | [1] | – | – | – | – | – | – | – | – | – | 1 | – | – |
| *R. lunulatus* | [1] | 1 | – | – | – | – | – | – | – | – | – | – | – |
| *R. cuspidatus* | [1] | – | – | – | – | – | – | 1 | – | – | – | – | – |
| *R. sulcatus* | [1] | – | – | – | – | – | – | – | 1 | – | – | – | – |
| | | {639} | {15} | {114} | {74} | {37} | {20} | {3} | {1} | {6} | {2} | {46} | {3} |
| Immature ticks | | | | | | | | | | | | | |
| *Haemaphysalis sp.* | [180] | 72 | 11 | 63 | 7 | 10 | 7 | – | – | – | 1 | 9 | – |
| *Ixodes* sp. | [83] | 19 | 7 | 27 | 16 | 2 | 2 | – | – | 2 | 2 | 6 | – |
| *Rhipicephalus* sp. | [42] | 4 | 5 | 6 | – | – | 1 | – | – | 1 | 19 | 4 | – |
| *Amblyomma* sp. | [2] | – | – | – | – | – | – | – | – | – | – | – | 2 |
| | | {95} | {23} | {96} | {25} | {12} | {10} | {0} | {0} | {3} | {22} | {19} | {2} |

960 records of adult ticks and 307 records of immature ticks were made from a total of 556 mammals between January 1976 and November 1978. ( ) total number of hosts of a given species; [ ] total number of records of a given tick species or genus; { } total number of records from a given host species.
BB, bushbuck; BLD, black duiker; BTP, African brush-tailed porcupine; BYD, bay duiker; CIV, African civet; GR, giant pouched rat; Lags, lagomorphs; MD, Maxwell's duiker; RA, royal antelope; RFD, red-flanked duiker; RRH, red river hog; TH, Togo hare.

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Table 4. Results of surveys at the Atwemonom Bushmeat market at Kumasi, Ashanti Region, Ghana: number of individuals of a host species infested with adult ticks of a particular species or immature ticks (nymphs and/or larvae) of a particular tick genus.

| | | Host species | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ungulates (Artiodactyls) | | | | | | | | | | | |
| | | Bovids | | | | | Rodents | | | Carnivores | | Primates | Pholidotes |
| | | BB (98) | RA (30) | BLD (99) | MD (86) | RFD (3) | GC (89) | GR (5) | GS (5) | CIV (15) | CHE (1) | Chimp (1) | Pangolin (23) |
| Adult ticks | | | | | | | | | | | | | |
| *Haemaphysalis parmata* | [313] | 93 | 26 | 89 | 80 | 3 | 15 | 3 | – | 3 | – | – | 1 |
| *Ixodes moreli* | [79] | 32 | 1 | 29 | 12 | – | 3 | – | – | 2 | – | – | – |
| *Rhipicephalus simpsoni* | [62] | 3 | 1 | 3 | 2 | – | 52 | 1 | – | – | – | – | – |
| *I. muniensis* | [56] | 17 | 2 | 19 | 12 | – | 4 | – | – | 2 | – | – | – |
| *R. ziemanni* | [32] | 18 | 3 | 4 | 6 | – | – | – | – | 1 | – | – | – |
| *Amblyomma compressum* | [27] | 2 | – | 2 | – | – | – | – | – | – | – | – | 23 |
| *I. aulacodi* | [26] | 1 | – | 1 | – | – | 24 | – | – | – | – | – | – |
| *Hae. leachi* | [20] | – | – | 1 | 2 | – | 2 | – | – | 15 | – | – | – |
| *I. cumulatimpunctatus* | [7] | 5 | – | – | – | – | 1 | – | – | 1 | – | – | – |
| *Hae. houyi* | [3] | – | – | – | – | – | – | – | 3 | – | – | – | – |
| *I. rasus* | [2] | – | – | – | – | – | 1 | – | – | 1 | – | – | – |
| *Am. variegatum* | [2] | 1 | – | – | – | – | – | – | – | – | 1 | – | – |
| *Hae. aciculifer* | [1] | – | – | – | – | – | – | – | 1 | – | – | – | – |
| *I. loveridgei* | [1] | – | – | – | – | – | – | 1 | – | – | – | – | – |
| *I. oldi* | [1] | – | – | – | – | – | – | – | – | 1 | – | – | – |
| | | {172} | {33} | {148} | {114} | {3} | {102} | {5} | {4} | {27} | {1} | {0} | {24} |
| Immature ticks | | | | | | | | | | | | | |
| *Haemaphysalis* sp. | [69] | 5 | 8 | 15 | 23 | – | 7 | 1 | 2 | 4 | – | – | 4 |
| *Ixodes* sp. | [53] | 4 | 1 | 17 | 9 | – | 20 | – | 1 | 1 | – | – | – |
| *Amblyomma* sp. | [28] | – | – | 3 | 1 | – | 13 | – | – | – | – | 1 | 10 |
| *Rhipicephalus* sp. | [5] | 1 | 1 | 1 | 1 | – | 1 | – | – | – | – | – | – |
| | | {10} | {10} | {36} | {34} | {0} | {41} | {1} | {3} | {5} | {0} | {1} | {14} |

633 records of adult ticks and 155 records of immature ticks were made from a total of 455 mammals between June 1975 and January 1978. ( ) total number of hosts of a given species; [ ] total number of records of a given tick species or genus; { } total number of records from a given host species.
BB, bushbuck; BLD, black duiker; CHE, cheetah; CIV, African civets plus two palm civets; GC, grasscutter; GR, giant pouched rat; GS, ground squirrel; MD, Maxwell's duiker; RA, royal antelope; RFD, red-flanked duiker.

Table 5. Results of surveys of animals from Swedru and surrounding villages at the Mankesim bushmeat centre, Central Region, Ghana: number of individuals of a host species infested with adult ticks of a particular species or immature ticks (nymphs and/or larvae) of a particular tick genus.

| | | Host species | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Ungulates (Artiodactyls) | | | | | | | | |
| | | Bovids | | | | | Suids | Rodents | | |
| | | BB (3) | RA (10) | MD (22) | BLD (8) | BYD (1) | RRH (2) | GC (50) | GR (1) | BTP (1) |
| Adult ticks | | | | | | | | | | |
| *Rhipicephalus simpsoni* | [35] | – | 2 | – | 1 | – | 2 | 29 | 1 | – |
| *Ixodes aulacodi* | [33] | 1 | 3 | 4 | 3 | – | – | 22 | – | – |
| *Haemaphysalis parmata* | [25] | – | 6 | 14 | 3 | – | – | 2 | – | – |
| *R. ziemanni* | [5] | 2 | 1 | – | – | 1 | – | 1 | – | – |
| *R. senegalensis* | [2] | – | – | – | 1 | – | – | – | – | 1 |
| | | {3} | {12} | {18} | {8} | {1} | {2} | {54} | {1} | {1} |
| Immature ticks | | | | | | | | | | |
| *Rhipicephalus* sp. | [28] | – | – | 3 | 2 | – | – | 23 | – | – |
| *Ixodes* sp. | [11] | – | 1 | 1 | 1 | – | – | 8 | – | – |
| *Haemaphysalis* sp. | [5] | – | – | 4 | – | – | – | 1 | – | – |
| *Amblyomma* sp. | [3] | – | – | – | – | – | – | 3 | – | – |
| | | {0} | {1} | {8} | {3} | {0} | {0} | {35} | {0} | {0} |

100 records of adult ticks and 47 records of immature ticks were made from a total of 98 mammals between February 1976 and April 1977. ( ) total number of hosts of a given species; [ ] total number of records of a given tick species or genus; { } total number of records from a given host species.
BB, bushbuck; BLD, black duiker; BTP, African brush-tailed porcupine; BYD, bay duiker; GC, grasscutter; GR, giant pouched rat; MD, Maxwell's duiker; RA, royal antelope; RRH, red river hog.

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Table 6. Results of surveys at Kantamanto Market, Greater Accra, Ghana: number of individuals of a host species infested with adult ticks of a particular species or immature ticks (nymphs and/or larvae) of a particular tick genus.

| | | Host species | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ungulates (Artiodactyls) | | | | | | | | | |
| | | Bovids | | | | | Suids | Rodents | | | Primates |
| | | BB (5) | RA (12) | MD (41) | BLD (7) | BYD (2) | RRH (1) | GR (12) | GC (1) | BTP (1) | SNM (1) |
| Adult ticks | | | | | | | | | | | |
| *Rhipicephalus senegalensis* | [41] | 2 | 8 | 23 | 4 | 1 | – | 1 | 1 | – | 1 |
| *Ixodes aulacodi* | [18] | 1 | 2 | 8 | 2 | – | – | 5 | – | – | – |
| *Haemaphysalis parmata* | [12] | 1 | 1 | 8 | 2 | – | – | – | – | – | – |
| *R. simpsoni* | [11] | – | 2 | 1 | 1 | – | – | 6 | – | 1 | – |
| *R. ziemanni* | [7] | 1 | – | 5 | – | 1 | – | – | – | – | – |
| *I. moreli* | [1] | 1 | – | – | – | – | – | – | – | – | – |
| *R. lunulatus* | [1] | – | – | – | – | – | 1 | – | – | – | – |
| | | {6} | {13} | {45} | {9} | {2} | {1} | {12} | {1} | {1} | {1} |
| Immature ticks | | | | | | | | | | | |
| *Rhipicephalus* sp. | [9] | – | 2 | 5 | – | – | – | 2 | – | – | – |
| *Amblyomma* sp. | [2] | – | 1 | 1 | – | – | – | – | – | – | – |
| *Haemaphysalis* sp. | [2] | – | – | 2 | – | – | – | – | – | – | – |
| | | {0} | {3} | {8} | {0} | {0} | {0} | {2} | {0} | {0} | {0} |

91 records of adult ticks and 13 records of immature ticks were made from a total of 83 mammals between February 1976 and July 1976.
( ) total number of hosts of a given species; [ ] total number of records of a given tick species or genus; { } total number of records from a given host species.
BB, bushbuck; BLD, black duiker; BTP, African brush-tailed porcupine; BYD, bay duiker; GC, grasscutter; GR, giant pouched rat; MD, Maxwell's duiker; RA, royal antelope; RRH, Red river hog; SNM, spot-nose monkey.

The frequency of the immature ticks belonging to the different genera recorded at the different collection points (table 7) was calculated as follows:

$$\frac{\text{Number of records of immature ticks of a given genus from a particular collection point}}{\text{Total number of records of immature ticks of that genus from all collection points.}} \times 100$$

All the mammalian host species, on which tick species belonging to the family Ixodidae have been recorded in Ghana, are listed in appendix 1 together with the tick species, whose identities can be verified, found on the individual hosts. This appendix includes the combinations of tick species and host species for the 25 tick species described here, for ticks held in the University of Edinburgh's Main Tick Collection (UEMTC) that were collected from either wild mammals by the Ghana Wildlife Department (GWLD) or domestic mammals in Ghana between 1964 and 1966 by E.N. Oppong, and for ticks reported by other authors. The data were used to assess which of the tick–host combinations found in the ticks from wild mammals described here had not been recorded before in Ghana or, as far as can be judged, elsewhere in Africa. The publications used for the comparisons are given in the text. A summary of the previously unrecorded combinations is given in table 8.

## Results

### *Summary of ticks collected from wild mammals and humans in Ghana*

Overall, 21 species of ticks belonging to five genera of the family Ixodidae were collected from wild mammals. Collections from humans at Bia National Park yielded a further genus and four species, not found elsewhere. Eight species not previously reported in Ghana occurred in the collection. The 1852 records of adult ticks and 558 records of immature ticks were collected from a total of 1260 wild mammals belonging to 29 species representing 14 families and six orders.

### *Updated list of tick species reported in Ghana*

The updated list of the tick species recorded from Ghana to date is given in table 1. It includes the first definitive records of the species, as far as is known, and, where taxonomic revisions indicate some uncertainty in tick identification, the reference confirming the occurrence of that species in Ghana. The total number of tick species belonging to the family Ixodidae is 41 representing six genera; the number belonging to the family Argasidae is four representing three genera.

### *Distribution and abundance of mammals and ticks in different vegetation zones*

The 15 species of mammals (68 specimens in all) trapped in the Guinea savanna at Mole National Park (table 2) were typical inhabitants of savanna woodland, e.g. kongonis, warthogs and Togo hares. Together they were infested with adults of ten species of ticks and immature ticks belonging to two genera (*Amblyomma*, *Rhipicephalus*) (104 records in all). Of the 12 species of mammals (556 specimens in all) caught in the drier regions of semi-deciduous forest and examined at the bushmeat centre in Sunyani (table 3), the most numerous animals by far were bushbucks followed by forest duikers, in particular Maxwell's duikers. Other animals included royal antelopes, civets and brush-tailed porcupines. Together these mammals were infested with

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Table 7. Frequency of the adults of the 21 tick species and the four genera of immature ticks found on wild animals at five collection points in three different vegetation zones in Ghana.

| | | Savanna | Semi-deciduous forest | | | Coastal zone |
|---|---|---|---|---|---|---|
| | | Mole | Sunyani | Kumasi | Swedru | Kantamanto |
| Adult ticks | | | | | | |
| *Rhipicephalus (Boophilus) geigyi* | (1) | 100 | 0 | 0 | 0 | 0 |
| *Hyalomma truncatum* | (1) | 100 | 0 | 0 | 0 | 0 |
| *R. sulcatus* | (23) | 60 | 40 | 0 | 0 | 0 |
| *R. cuspidatus* | (9) | 89 | 11 | 0 | 0 | 0 |
| *Amblyomma variegatum* | (14) | 86 | 0 | 14 | 0 | 0 |
| *Haemaphysalis aciculifer* | (5) | 80 | 0 | 20 | 0 | 0 |
| *R. lunulatus* | (11) | 82 | 9 | 0 | 0 | 9 |
| *R. senegalensis* | (50) | 14 | 0 | 0 | 4 | 82 |
| *R. simpsoni* | (118) | 3 | 6 | 53 | 30 | 9 |
| *Ixodes oldi* | (12) | 0 | 92 | 8 | 0 | 0 |
| *I. cumulatimpunctatus* | (50) | 0 | 86 | 14 | 0 | 0 |
| *I. muniensis* | (279) | 0 | 80 | 20 | 0 | 0 |
| *Hae. leachi* group | (44) | 0 | 54 | 46 | 0 | 0 |
| *I. rasus* | (3) | 0 | 33 | 66 | 0 | 0 |
| *Am. compressum* | (30) | 0 | 10 | 90 | 0 | 0 |
| *Hae. houyi* | (3) | 0 | 0 | 100 | 0 | 0 |
| *I. loveridgei* | (1) | 0 | 0 | 100 | 0 | 0 |
| *R. ziemanni* | (178) | 0 | 75 | 18 | 3 | 4 |
| *Hae. parmata* | (799) | 0 | 56 | 39 | 6 | 2 |
| *I. moreli* | (135) | 0 | 41 | 59 | 0 | 1 |
| *I. aulacodi* | (85) | 0 | 9 | 31 | 39 | 21 |
| Immature ticks: | | | | | | |
| *Amblyomma* sp. | (64) | 45 | 3 | 44 | 5 | 3 |
| *Rhipicephalus* sp. | (91) | 8 | 46 | 6 | 31 | 10 |
| *Haemaphysalis* sp. | (256) | 0 | 70 | 27 | 2 | 1 |
| *Ixodes* sp. | (147) | 0 | 57 | 36 | 8 | 0 |

Frequency of adult ticks was calculated as the number of records of adult ticks of a given species from a particular collection point expressed as a percentage of the total number of records of adult ticks of that species collected from all collection points. Frequency of immature ticks was calculated as the number of records of immature ticks of a given genus from a particular collection point expressed as a percentage of the total number of records of immature ticks of that genus collected from all collection points. ( ) Total number of records for an adult tick species or immature ticks of a given genus.

adults of 14 species of ticks and immature ticks belonging to four genera (*Amblyomma*, *Haemaphysalis*, *Ixodes*, *Rhipicephalus*) (1267 records in all). Twelve species of mammals (455 specimens in all) were trapped in the moist semi-deciduous forest and transition zone with the Guinea savanna and examined at the bushmeat centre at Kumasi (table 4). The most numerous were bushbucks, black duikers, Maxwell's duikers and grasscutters, plus a number of civets (including two palm civets) and pangolins. Together these mammals were infested with adults of 15 species of ticks and immature ticks belonging to the four genera listed above (788 records in all). Ticks collected from a lion in the Zoological Gardens at Kumasi proved to be adult *Am. variegatum* (appendix 1). Nine species of mammals (98 specimens in all) caught in the transition zone between semi-deciduous forest and coastal thickets around Swedru were examined at the Mankesim bushmeat market (table 5). The most numerous were grasscutters, Maxwell's duikers and royal antelopes. Taken together they were infested by adults of five species of ticks and immature ticks belonging to four genera (147 records in all). Ten species of mammals (83 specimens in all) were obtained from the Kantamanto bushmeat market in Accra that receives animals from a wide area of the coastal zone (table 6); the most numerous being Maxwell's duikers, royal antelopes and giant pouched rats. Taken together they were infested with adults of seven species of ticks and immature ticks belonging to three genera (104 records in all).

### *Distribution and abundance of tick genera in different vegetation zones*

The distribution of adult ticks belonging to the six different ixodid genera recorded here (*Amblyomma, Dermacentor*, *Ixodes*, *Haemaphysalis*, *Hyalomma*, *Rhipicephalus* with the last genus being understood to include the subgenus *Boophilus*) varied between the different vegetation zones (table 7). The only genera found in all zones were *Amblyomma*, *Haemaphysalis* and *Rhipicephalus*. Species of *Ixodes* were found mainly in the semi-deciduous forests, occasionally in the coastal zone, and not in the Guinea savanna. Members of the subgenus *R. (Boophilus)* and the genus *Hyalomma* were found only in the Guinea savanna. The only species of *Dermacentor* (*Dermacentor circumguttatus* Neumann) was found in the Bia National Park. The abundance of members of the different genera differed markedly. There were only one or two records of adults of species belonging to the sub-genus *R. (Boophilus)* and the genera *Hyalomma* and *Dermacentor,* 44 records of adult

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Table 8. Summary of the 56 previously unrecorded combinations of tick species and host species recorded in the collection of Ghanaian ticks belonging to the family Ixodidae described in this paper.

| Tick species | Previously unrecorded hosts |
|---|---|
| *Amblyomma compressum* | Black duiker |
| *Am. variegatum* | Cheetah, jackal, lion, waterbuck |
| *Dermacentor circumguttatus* | Human |
| *Haemaphysalis aciculifer* | Ground squirrel, kongoni |
| *Hae. leachi* group | Bay duiker, black duiker, Maxwell's duiker |
| *Hae. parmata* | African brush-tailed porcupine, red-flanked duiker, white-tailed mongoose |
| *Ixodes aulacodi** | Giant pouched rat, black duiker, bushbuck, Maxwell's duiker, royal antelope |
| *I. cumulatimpunctatus* | Grasscutter |
| *I. loveridgei* | Giant pouched rat |
| *I. moreli** | African civet, grasscutter, Maxwell's duiker, red-flanked duiker, royal antelope |
| *I. muniensis* | Grasscutter, red-flanked duiker |
| *I. rasus* | African brush-tailed porcupine, human |
| *I. vanidicus* | Human |
| *Rhipicephalus (Boophilus) geigyi* | Kongoni |
| *R. lunulatus* | Kob, kongoni |
| *R. senegalensis** | African brush-tailed porcupine, black duiker, giant pouched rat, grasscutter, kob, Maxwell's duiker, monkey, royal antelope |
| *R. simpsoni** | Black duiker, bushbuck, crested porcupine, kob, leopard, Maxwell's duiker, red-flanked duiker, red river hog |
| *R. sulcatus* | Kongoni, marsh mongoose, monkey |
| *R. ziemanni* | Crested porcupine, grasscutter, red-flanked duiker |

Nineteen of the 25 tick species in the collection were recorded in new combinations; only six species (*Am. tholloni, Hae. houyi, Hy. truncatum, I. oldi, R. complanatus, R. cuspidatus)* occurred only on previously recorded host species; data derived from appendix 1.
*Four tick species were involved in nearly half (26) the combinations*: I. aulacodi, I. moreli, R. senegalensis, R. simpsoni.* Fifteen tick species were involved in the other 30 combinations.

*Amblyomma* spp., 851 records of adult *Haemaphysalis* spp., 567 records of adult *Ixodes* spp. and 395 records of adult *Rhipicephalus* spp. Immature ticks of only four of the genera were found: *Amblyomma, Haemaphysalis*, *Ixodes*, *Rhipicephalus*; the immature ticks of species of *Amblyomma* and *Rhipicephalus* being more widespread than the immature ticks of species of *Haemaphysalis* or *Ixodes*.

### *Distribution and abundance of tick species in different vegetation zones*

The distribution of the adult ticks of the different species collected from bushmeat markets and the Mole National Park varied markedly between the different vegetation zones (table 7). *Rhipicephalus (Boophilus) geigyi* and *Hy. truncatum* were found only in Guinea savanna and only in very low numbers. *Rhipicephalus sulcatus, Rhipicephalus cuspidatus* Neumann, *Am. variegatum* and *Hae. aciculifer* were found mostly in the Guinea savanna but extended into the semi-deciduous forest. The following species were found only in the semi-deciduous forest: *Ixodes oldi* Nuttall, *I. cumulatimpunctatus*, *Ixodes muniensis* Arthur & Burrow, *Hae. leachi*, *I. rasus, Am. compressum, Haemaphysalis houyi* Nuttall & Warburton, *Ixodes loveridgei* Arthur. Other species were more widespread. *Rhipicephalus lunulatus, R. senegalensis* and *Rhipicephalus simpsoni* Nuttall occurred in all the vegetation zones. *Rhipicephalus ziemanni*, *Hae. parmata*, *Ixodes moreli* Arthur and *Ixodes aulacodi* Arthur were found in semi-deciduous forest and the coastal zone.

Six species were collected from game rangers in Bia National Park over a four day period in October 1977: *Amblyomma tholloni* Neumann (two collections: 4 males; 2 females; 1 nymph); *D. circumguttatus* (two collections: 6 females); *I. rasus* (one collection: 1 female); *Ixodes vanidicus* Schulze (one collection: 1 male; 1 female); *Rhipicephalus complanatus* Neumann (four collections: 8 males, 10 females); *R. ziemanni* (two collections: 1 male, 2 females).

In order of abundance of records, the 25 species found on the wild animals and humans were *Hae. parmata* (799), *I. muniensis* (279), *R. ziemanni* (180), *I. moreli* (135), *R. simpsoni* (118), *I. aulacodi* (85), *R. senegalensis* (50), *I. cumulatimpunctatus* (50), *Hae. leachi* (44), *Am. compressum* (30), *R. sulcatus* (23), *Am. variegatum* (14), *I. oldi* (12), *R. lunulatus* (11), *R. cuspidatus* (9), *Hae. aciculifer* (5), *Hae. houyi* (3), *I. rasus* (4), *R. complanatus* (4), *Am. tholloni* (2), *D. circumguttatus* (2), *R. (Boophilus) geigyi* (1), *Hy. truncatum* (1), *I. loveridgei* (1), *I. vanidicus* (1).

### *Patterns of tick species:host species associations*

The patterns of associations between ticks and their host species summarized in tables 2–6 indicated that certain ticks were closely associated with members of related groups of host species. Thus *Am. compressum* was predominantly associated with pangolins, *Hae. leachi* and *I. oldi* with small carnivores, *I. aulacodi* and *R. simpsoni* with rodents. A number of species (*Hae. aciculifer, Hae. parmata, I. moreli, I. muniensis*) were mostly found on bovids; one species (*R. cuspidatus*) occurred only on suids. Five species were found on both bovids and suids: *Am. variegatum, I. cumulatimpunctatus, R. lunulatus, R. ziemanni, R. senegalensis*. Only *R. sulcatus* was found more evenly distributed on hosts belonging to different orders of mammals, namely lagomorphs, bovids and carnivores. These observations showed that some ticks occurred in the savanna feeding on bovids and suids, while others occurred in forests feeding on small bovids, large rodents and small carnivores.

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*Different combinations of ixodid tick species and mammalian host species recorded in Ghana*

The mammalian species, on which the ticks belonging to the family Ixodidae in this collection were recorded, and the tick species, whose identities can be verified, found on the individual host species are summarized in appendix 1. For the sake of completeness, this appendix includes: *Am. splendidum* described by Simpson (1914); tick species from wild mammals described by Campbell *et al*. (1978) and Ntiamoa-Baidu (1980); specimens of *Am. tholloni* and *D. circumguttatus* collected from an elephant by the GWLD now held in the UEMTC; the following ticks collected from domestic animals in Ghana by E.N. Oppong in the 1960s, now held in the UEMTC: *Am. variegatum*, from cattle and sheep, *Hae. leachi* from a domestic cat, *R. sanguineus* from a domestic dog; and ticks described on domestic stock by Walker & Koney (1999). The completed list revealed a total of 151 different combinations of tick species:host species.

Of the 121 combinations of tick species and host species found on the wild mammals and humans described in this paper (appendix 1), 56 combinations are probably hitherto unrecorded combinations, based on comparisons with the following published records of the hosts of these ticks in Ghana (Campbell *et al*., 1978; Ntiamoa-Baidu, 1980, 1986, 1987a,b), the Ivory Coast (Aeschlimann, 1967), Cameroon (Morel & Mouchet, 1958, 1965), Burkina Faso (Morel, 1978), French West Africa (Morel, 1958), the Sudan and other parts of Africa (Hoogstraal, 1956), Tanzania (Yeoman & Walker, 1967) and Kenya (Walker, 1974) – and from monographs on the genera *Ixodes* (Arthur, 1965), *Amblyomma* (Robinson, 1926) and *Rhipicephalus* (Walker *et al*., 2000).

Nineteen of 25 species of ticks in the collection were involved in the 56 newly recorded combinations between ticks and their host species (table 8); just six species were found only on previously recorded hosts: *Am. tholloni*, *Hae. houyi*, *Hy. truncatum*, *I. oldi*, *R. complanatus*, *R. cuspidatus*. The new combinations could be broadly assigned to five different categories.

The first category consisted of a number of 'new' combinations that reflected previous findings as to the host types predominantly infested by the tick species. The records of *I. moreli* on duikers and royal antelope and *Hae. aciculifer* and *R. (Boophilus) geigyi* on the kongoni accorded with these ticks being thought of predominantly as ticks of ungulates. The new records of *R. senegalensis* on artiodactyls, rodents and a monkey, *R. lunulatus* on ungulates, and *R. sulcatus* on the kongoni and a monkey agreed with previous observations of these tick species being found on a wide range of hosts.

The second category consisted of records of tick species on members of mammalian families or mammalian species not previously recorded as hosts for such tick species. Both *I. aulacodi* and *R. simpsoni* have often been reported to be predominantly or solely parasites of the grasscutter. In this collection, however, 40% of the records of *I. aulacodi* and 21% the records of *R. simpsoni* were from other host species. The previously unrecorded hosts for *I. aulacodi* included four species of ungulates (bushbuck, Maxwell's duiker, black duiker and royal antelope) and the giant pouched rat. *Rhipicephalus simpsoni* also occurred on a number of ungulates (bushbuck, Maxwell's duiker, black duiker, kob and red river hog), as well as carnivores (civet, leopard) and the crested porcupine. Finding members of the *Hae. leachi* group on duikers was also unexpected as these ticks have not previously been recorded from these ungulates.

The third category included a number of tick species found rarely (*I. loveridgei*) or only infrequently (*Am. compressum*, *Am. variegatum*, *Hae. parmata*) on previously unrecorded hosts; *Am. compressum* being predominantly associated with pangolins, *Am. variegatum* and *Hae. parmata* with ungulates. The fourth category consisted of three new records of ticks (*I. rasus, I. vanidicus, D. circumguttatus*) collected from humans (game rangers, in the Bia National Park); such incidental records on humans are well documented.

The last category consisted of ticks found on host species like the red-flanked duiker, for which no records have been found, and the grasscutter, an animal that has not been examined extensively before. Five combinations represent the records of *Hae. parmata, I. moreli, I. muniensis*, *R. simpsoni* and *R. ziemanni* on the red-flanked duiker. These are the same tick species as found on other forest duikers in Ghana. Five combinations represent the following ticks found on the grasscutter: *I. cumulatimpunctatus*, *I. moreli, I. muniensis*, *R. senegalensis* and *R. ziemanni*. The grassscutter was an unexpected host for the last five ticks as they are usually considered to be predominantly associated with ungulates.

Most of the records that differed markedly from previous findings therefore either related to ticks for which there is relatively little previous knowledge or that were rare in the collection, or to host species for which there is little or no previous knowledge. Of the ticks involved in the 56 new tick–host combinations reported here, relatively few tick species were found on what might be considered totally unexpected hosts, when the types of hosts on which they were found predominantly in this Ghanaian collection or in the collections described by other authors are taken into consideration.

## Discussion

This study provided much new information and clarified many early reports on the tick species of Ghana, their distribution in different vegetation zones and the identities of their wild mammalian hosts. The 25 species of ticks described here bring the total number of tick species belonging to the family Ixodidae in Ghana to date to 41. Eight species appear to be new records for Ghana. The data reported here showed that some tick species occurred in savanna feeding mainly on large bovids and/or suids as their main hosts, and that other species occurred in forests feeding mainly on small bovids, large rodents or small carnivores. Very few of the tick species found on wild mammals were the same as the tick species recorded previously from ticks of domestic stock in Ghana (Walker & Koney, 1999). Of the 121 tick species:host species combinations found in the collection, 56 combinations appeared to be new reports. The overall number of tick species:host species combinations reported for ticks belonging to the family Ixodidae in Ghana now totals 151. This study provided a substantial increase in the number of records of many tick species and in the number of many mammal species sampled. For example, previous records for *R. senegalensis*, *R. sulcatus* and *R. ziemanni* were 85, 71 and 70 respectively (Walker *et al*., 2000); the records for these ticks reported here are 49, 23 and 178 respectively. The number of collections from pangolins in Africa is almost doubled: Cumming (1998) reported records from 28 pangolins; the number of pangolins examined here

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was 26. This study on the ticks obtained from Ghanaian wild mammals complements existing knowledge of the ticks infesting wild animals and domestic stock in other neighbouring or zoogeographically similar regions of West Africa (Rageau, 1951; Unsworth, 1952; Morel, 1958, 1978; Morel & Mouchet, 1958, 1965; Morel & Magimel, 1959; Morel & Finelle, 1961; Morel & Graber, 1961; Aeschlimann, 1967; Matthyse, 1984; Gueye *et al*., 1989).

When the Ghanaian ticks described here were collected, the existence of reviews on *Boophilus, Dermacentor* and *Ixodes* (Arthur, 1960, 1965) and the work of Hoogstraal (1956) enabled YN-B, aided by J.A. Campbell, to identify most of the specimens in the Ghanaian collections including the different *Ixodes* species. Their first published studies on the Ghanaian ticks of wild animals focused on the ticks of the grasscutter, *T. swinderianus*. They observed *I. aulacodi* and *R. simpsoni* as the predominant species on this mammal, plus occasional specimens of *Hae. parmata*, *Hy. impressum*, *I. moreli*, *I. muniensis* (Campbell *et al*., 1978), *Am. compressum*, *Hae. leachi*, *I. cumulatimpunctatus*, *I. rasus* and *R. ziemanni*, with single specimens of *Amblyomma paulopunctatum* Neumann and *Am. nuttalli* (Ntiamoa-Baidu, 1980). While seven of these species had been reported previously in Ghana, six species appear to have been new records for Ghana: *Am. compressum, Am. paulopunctatum, I. aulacodi, I. moreli, I. muniensis* and *R. simpsoni*.

The creation of an electronic database of the ticks collected from a range of wild mammals by YN-B was accompanied by a reappraisal of many of the specimens of *Haemaphysalis* and *Rhipicephalus* according to the revisions of Camicas *et al*. (1998), Pegram *et al*. (1987a,b,c), Pegram & Walker (1988) and Walker *et al*. (1988). Querying the database confirmed that members of the genera *Amblyomma, Haemaphysalis*, *Hyalomma*, *Ixodes* and *Rhipicephalus* and the sub-genus *R. (Boophilus),* as well as *Am. variegatum*, *Hae. aciculifer* and *Hae. parmata* were present in Ghana. It also confirmed that a number of ticks that have undergone recent taxonomic revisions occurred, i.e. members of the *Hae. leachi* group, *Hy. truncatum, I. rasus, R. lunulatus* (syn. *R. tricuspis*), *R. senegalensis, R. sulcatus* and *R. ziemanni*. The presence of *R. sanguineus* sensu Pegram in Ghana was confirmed by the specimens collected from a dog in Ghana in the University of Edinburgh's Main Tick Collection. The new data set augmented the records of six species first reported in Ghana by Campbell *et al*. (1978) (*I. aulacodi*, *I. moreli*, *I. muniensis*, *R. simpsoni*) and Ntiamoa-Baidu (1980) (*Am. compressum*, *I. rasus*) and, most interestingly, revealed for the first time, as far as is known, the presence of eight other species in Ghana, namely, *Am. tholloni*, *D. circumguttatus*, *Hae. houyi*, *I. loveridgei*, *I. oldi*, *I. vanidicus*, *R. complanatus, R. cuspidatus*. The updated list of Ghanaian ticks comprises a total of nine genera and 45 species: 41 species of ticks belonging to six genera of the family Ixodidae and four species of ticks belonging to three genera of the family Argasidae (table 1). As well as new and confirmatory records made by Campbell *et al*. (1978), Ntiamoa-Baidu (1980) and this study, the list includes the following seven tick species newly described on domestic stock by Walker & Koney (1999): *Haemaphysalis spinulosa* Neumann, *Hyalomma marginatum rufipes* Koch, *Rhipicephalus (Boophilus) annulatus* (Say), *Rhipicephalus (Boophilus) decoloratus* (Koch), *R. (Boophilus) geigyi*, *R. evertsi evertsi* and *Rhipicephalus sanguineus* (*incertae sedis*).

The occurrence of the tick species at the different collection points indicated that some ticks occurred in a number of vegetation zones while others were more restricted in their distribution. The species of *R. (Boophilus)* and *Hyalomma* were found in the dry Guinea savanna zone. The genus *Ixodes* was mainly confined to semi-deciduous forest, except for one record of *I. moreli* and several of *I. aulacodi* from the coastal zone. The genera *Amblyomma*, *Haemaphysalis* and *Rhipicephalus* occurred in all vegetation zones, including the relatively dry coastal belt. Some species of these three genera were widespread, occurring in both the moist semi-deciduous forest and the coastal grassland zones; others were confined to certain vegetation zones. The occurrence of the different mammalian species brought to the bushmeat centres in the different vegetation zones agreed with their patterns of distributions and ecological and nutritional requirements as described by Kingdon (2001). The observed differences in distribution of tick species may be taken to reflect the combined constraints of finding a suitable environment, with respect to temperature/humidity/cover for survival and maturation or egg-laying, when off the host and of encountering a suitable host on which to feed and find a mate as reviewed by Sonenshine (1993). Evidence that environmental factors are instrumental in determining geographical range was provided by experimental studies that showed that *I. aulacodi* is much less resistant to desiccation and less tolerant of high temperatures than *R. simpsoni* (Ntiamoa-Baidu, 1987a,b). Such differences may explain the different distributions of the two ticks. While *I. aulacodi* appears to be restricted to humid West African countries, *R. simpsoni* occurs throughout the range of the grasscutter, including dry and semi-desert areas of East and Central Africa.

Many of the patterns of associations between tick species and host taxa reported here were the same as those described by Hoogstraal & Aeschlimann (1982). These authors noted that some ticks were exclusively associated with one host species, e.g. *Am. compressum* with pangolins, while others were strongly associated with members of one order, e.g. *I. oldi* and *Hae. leachi* with small carnivores and *Hae. parmata*, *R. cuspidatus* and *R. ziemanni* with either bovids and/or suids; only a very few tick species, e.g. *R. sulcatus*, had a wide host range. Our general observations therefore supported their view that most ticks display some varying degree of host specificity in that they are commonly found associated with certain host species but are also found on other hosts, although less commonly.

Querying the database of adult ticks collected from wild mammals and humans in Ghana revealed a total of 121 different combinations of tick species:host species. Just over half (65/121) of these combinations were the same as those recorded for these tick species in other regions of Africa (Hoogstraal & Aeschlimann, 1982). Of the 56 new combinations, most agreed with previous observations as to the host types predominantly infested by the tick species in question, including the five records on the red-flanked duiker that reflected records of tick species found on other species of duikers. The few exceptional combinations, that differed markedly from previous findings, either involved tick species for which there is little previous knowledge or that were rare or infrequent in the collection, or involved host species for which there is little previous knowledge.

The tick species found on wild animals only overlapped slightly with those found on domestic stock by Walker & Koney (1999). Relatively few of the adults of tick species

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found on wild mammals, namely *Am. variegatum*, *R. (Boophilus) geigyi*, members of the *Hae. leachi* group, *Hy. truncatum*, *R. lunulatus*, *R. senegalensis*, were recorded on domestic stock. None of the most common ticks on domestic stock, i.e. *R. (Boophilus) annulatus*, *R. (Boophilus) decoloratus*, *Hy. marginatum rufipes*, *R. evertsi evertsi*, were found on wild animals. This was surprising, both in view of the large numbers of wild ungulates examined that might have been expected to be hosts for the ticks that occur on domestic ungulates (Hoogstraal, 1956) and because both studies appeared to survey very similar vegetation zones. It is not clear if these findings were due to host specificity, or because domestic stock do not frequent the same habitats as wild mammals, or to a combination of both factors. Whatever the cause, it appears that the adults of tick species found on domestic stock do not use wild ungulates as significant maintenance hosts, with the possible exception of *Am. variegatum* and *R. senegalensis*. This situation reflects the overall situation recorded for ticks of domestic cattle, sheep and goats throughout sub-tropical and tropical regions of Africa, again with the exception of *Am. variegatum* and *R. senegalensis* (Walker *et al*., 2003). Until the identities of the immature amblyommid and rhipicephalid ticks found on wild mammals in Ghana are known, the possibilities that wild animals serve as hosts for some stages of the ticks of domestic stock and act as reservoirs of infections for domestic stock cannot be excluded. The fact that ticks of wild animals regularly act as reservoirs for zoonotic infections of humans (Hoogstraal, 1981; Sonenshine, 1993) suggests that these Ghanaian ticks may also pose a threat to humans in this way, but we have no information to confirm or disprove this point.

The tick fauna of Ghana is almost identical to that of the Ivory Coast to the west (Aeschlimann, 1967) and very similar to that of Burkina Faso to the north (Morel, 1978) and to Cameroon further east (Morel & Mouchet, 1958, 1965). The list of 45 species found in Ghana (table 1) resembles the list of 38 species of ixodid ticks and two species of argasid ticks recorded in the Ivory Coast from a comparable range of mammalian hosts (Aeschlimann, 1967; Morel & Mouchet, 1965). Although more host species were examined in the Ivory Coast than in Ghana, the list of ticks is very similar. Ticks recorded in Ghana but not in the Ivory Coast are *I. loveridgei*, *I. vanidicus*, *C. vespertilionis* and *O. moubata* on wild animals and *R. (Boophilus) decoloratus* and *Hae. spinulosa* on domestic stock. In contrast, only 25 species of ticks were recorded on wild animals in Burkina Faso, which has a much drier climate and comprises only Sudan and Guinea-Sudan savanna (Morel, 1978); the most notable feature being the absence of all *Ixodes* species, except for *I. aulacodi*. In this study, *Ixodes* spp. were mainly confined to semi-deciduous forest, a vegetation zone not found in Burkino Faso. In contrast, Cameroon comprises Sudan and Guinea savanna in the north, deciduous forest in the centre and rain forest in the south. The high number of tick species, 50 in all, described there (Morel & Mouchet, 1958, 1965) reflected the range of climate and vegetation and, to some extent, the wide range of host species examined. Many tick species found in Cameroon were the same as those found in Ghana, Ivory Coast and Burkina Faso. *Ixodes vanidicus* was among the ticks common to Ghana and Cameroon. The identities of the mammals on which adult Ghanaian ticks have been found (appendix 1) agree closely with the hosts of the same tick species in other West African countries as described by Aeschlimann (1967), Morel & Mouchet (1958, 1965) and Morel (1958) and as reviewed by Hoogstraal & Aeschlimann (1982). The pronounced similarities in the distribution and behaviour of the tick fauna of wild animals in Ghana and the Ivory Coast may be attributed to the overall similarities in climate, vegetation types and fauna in the two neighbouring countries (Morel, 1958; Aeschlimann, 1967; Sayer *et al*., 1992; Boitani *et al*., 1999; Walker & Koney, 1999).

Overall, the data showed that different tick species occurred in different vegetation zones, with certain species displaying a pronounced preference for certain groups of related host species. Some species were found in the savanna feeding mainly on large bovids and/or suids; other different species were found in forests feeding mainly on small bovids, large rodents or small carnivores. These observations support the concept that tick species are adapted both to specific climates and vegetation types as well as to particular host species or groups of related host species, as postulated by Hoogstraal & Aeschlimann (1982). The results also indicated that the collection provided a suitable data set with which to look for statistically significant evidence of host specificity and to try to understand why some authors claim that ticks may be host specific (Hoogstraal & Aeschlimann, 1982; Sonenshine, 1993; Cumming, 1998) while others claim they are not (Klompen *et al*., 1996).

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## Appendix 1

Tick species:host species combinations for members of the family Ixodidae found on members of the class Mammalia in Ghana. * First record of this tick species:host species combination as judged by comparison with published records of African ticks as cited in the text. **First record of tick species collected from this host species. All records refer to tick species described in this paper unless otherwise indicated. GWLD: collected by the Ghana Wildlife Department, now in University of Edinburgh Main Tick Collection (UEMTC); Oppong: collected by E.N. Oppong, now in UEMTC. Authorities for mammalian species as given in Wilson & Reeder (1993).

ORDER PRIMATES
- Family Hominidae
  - Man (*Homo sapiens* Linnaeus): *Amblyomma tholloni, Dermacentor circumguttatus *, Ixodes rasus*, I. vanidicus*, Rhipicephalus complanatus, R. ziemanni.*
- Family Pongidae
  - Chimpanzee (*Pan troglodytes* (Blumenbach)): *Amblyomma* immatures
- Family Cercopithecidae
  - Green monkey (*Chlorocebus aethiops* subsp. (Linnaeus)): *R. sulcatus**
  - Spot-nose monkey (*Cercopithecus c. petaurista* (Schreber)): *R. senegalensis**

ORDER PHOLIDOTA
- Family Manidae
  - Tree pangolin (*Manis tricuspis* Rafinesque)/ Pangolin (unknown species*): Am. compressum*, Haemaphysalis parmata, Amblyomma* and *Haemaphysalis* immatures

ORDER ARTIODACTYLA
- Family Bovidae
  - Buffalo (*Syncerus caffer* (Sparrman)): *Am. splendidum* (Simpson)
  - Domestic cattle (*Bos taurus* Linnaeus (syn *Bos indicus*)): (Walker & Koney, 1999 unless otherwise specified) *Am. variegatum* (Oppong), *Hyalomma marginatum rufipes, Hy. truncatum, R. (Boophilus) annulatus, R. (B.) decoloratus, R. (B.) geigyi, R. evertsi evertsi, R. senegalensis, Rhipicephalus* sp.
  - Bushbuck (*Tragelaphus scriptus* (Pallas)): *Am. compressum, Am. variegatum, Hae. parmata, I. aulacodi*, I. cumulatimpunctatus, I. moreli, I. muniensis, R. lunulatus, R. senegalensis, R. simpsoni*, R. ziemanni, Amblyomma, Haemaphysalis, Ixodes* and *Rhipicephalus* immatures
  - Domestic sheep (*Ovis aries* Linnaeus): (Walker & Koney, 1999 unless otherwise specified) *Am. variegatum* (Oppong*), R. (B.) decoloratus, R. (B.) geigyi, R. e. evertsi, R. lunulatus, R. senegalensis, Rhipicephalus* sp.
  - Domestic goats (*Capra hircus* Linnaeus): (Walker & Koney, 1999) *Am. variegatum, Hy. truncatum, Rhipicephalus* sp.
  - Maxwell's or grey duiker (*Cephalophus maxwelli* (H. Smith)): *Hae. leachi* group.*, *Hae. parmata, I. aulacodi*, I. cumulatimpunctatus, I. moreli*, I. muniensis, R. senegalensis*, R. simpsoni*, R. ziemanni, Amblyomma, Haemaphysalis, Ixodes* and *Rhipicephalus* immatures

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**Red-flanked duiker (*Cephalophus rufilatus* Gray): *Hae. parmata**, *I. moreli**, *I. muniensis**, *R. simpsoni**, *R. ziemanni**, *Haemaphysalis*, *Ixodes* and *Rhipicephalus* immatures
Black duiker (*Cephalophus niger* Gray): *Am. compressum**, *Hae. leachi* group*, *Hae. parmata*, *I. aulacodi**, *I. moreli*, *I. muniensis*, *R. senegalensis**, *R. simpsoni**, *R. ziemanni*, *Amblyomma*, *Haemaphysalis*, *Ixodes* and *Rhipicephalus* immatures
Bay duiker (*Cephalophus dorsalis* Gray): *Hae. leachi* group*, *Hae. parmata*, *I. cumulatimpunctatus*, *I. moreli*, *I. muniensis*, *R. senegalensis*, *R. ziemanni*, *Haemaphysalis*, *Ixodes* and *Rhipicephalus* immatures
Royal antelope (*Neotragus pygmaeus* (Linnaeus)): *Hae. parmata*, *I. aulacodi**, *I. moreli**, *I. muniensis*, *R. senegalensis**, *R. simpsoni*, *R. ziemanni*, *Amblyomma*, *Haemaphysalis*, *Ixodes* and *Rhipicephalus* immatures
Reedbuck (*Redunca redunca* (Pallas)): *Amblyomma* immatures
Kob (*Kobus kob* (Erxleben)): *Am. variegatum*, *Hae. aciculifer*, *R. lunulatus**, *R. senegalensis**, *R. simpsoni**, *Amblyomma* immatures
Waterbuck (*Kobus ellipsiprymnus* (Ogilby)): *Am. variegatum**, *R. lunulatus*, *Amblyomma* immatures
Kongoni or hartebeest (*Alcephalus buselaphus* (Pallas)): *Am. variegatum*, *Hae. aciculifer**, *R. (B.) geigyi**, *R. lunulatus**, *R. sulcatus**, *Amblyomma* immatures

Family Suidae
Common warthog (*Phacochoerus africanus* (Gmelin)): *Am. variegatum*, *Hy. truncatum*, *R. cuspidatus*, *R. senegalensis*, *R. sulcatus*, *Amblyomma* and *Rhipicephalus* immatures
Red river hog (*Potamochoerus porcus* (Linnaeus)): *I. cumulatimpunctatus*, *R. cuspidatus*, *R. lunulatus*, *R. simpsoni**, *R. ziemanni*, *Amblyomma* and *Rhipicephalus* immatures

ORDER PROBOSCIDEA
Family Elephantidae
Elephant (*Loxodonta africana* (Blumenbach)) *Am. tholloni* (GWLD), *D. circumguttatus* (GWLD)

ORDER LAGOMORPHA
Family Leporidae
Togo hare (*Lepus victoriae* Thomas (syn *L. saxatilis* F. Cuvier; syn. *L. crawshayi* de Winton)): *R. sulcatus*, *Rhipicephalus* immatures

ORDER RODENTIA
Family Thryonomyidae
Grasscutter or Savannah cane rat (*Thyronomys swinderianus* Temminck): *Am. nuttalli* (Ntiamoa-Baidu, 1980), *Am. paulopunctatum* (Ntiamoa-Baidu, 1980), *Hae. leachi* group, *Hae. parmata*, *Hy. impressum* (Ntiamoa-Baidu, 1980), *I. aulacodi*, *I. cumulatimpunctatus**, *I. moreli**, *I. muniensis**, *I. rasus*, *R. senegalensis**, *R. simpsoni*, *R. ziemanni**, *Amblyomma*, *Ixodes*, *Haemaphysalis* and *Rhipicephalus* immatures

Family Muridae
Giant pouched rat (*Cricetomys gambianus* Waterhouse): *Hae. parmata*, *I. aulacodi**, *I. cumulatimpunctatus*, *I. loveridgei**, *R. senegalensis**, *R. simpsoni*, *Haemaphysalis*, *Ixodes* and *Rhipicephalus* immatures

Family Hystricidae
African brush-tailed porcupine (*Atherurus africanus africanus* Gray): *Hae. parmata**, *I. rasus**, *R. senegalensis**, *R. simpsoni*, *Haemaphysalis*, *Ixodes* and *Rhipicephalus* immatures
Crested porcupine (*Hystrix cristata* Linnaeus): *R. simpsoni**, *Amblyomma* immatures

Family Sciuridae
Striped ground squirrel (*Xerus erythropus* (Desmarest)): *Hae. aciculifer**, *Hae. houyi*, *Haemaphysalis* and *Ixodes* immatures

ORDER CARNIVORA
Family Canidae
Side-striped jackal (possibly *Canis adustus* Sundevall): *Am. variegatum**, *R. sulcatus*
Domestic dog (*Canis familiaris* Linnaeus): *Hae. leachi* group. (Walker & Koney, 1999), *R. sanguineus* (Oppong; Walker & Koney, 1999)

Family Felidae
Cheetah (*Acinonyx jubatus* (Schreber)): *Am. variegatum**
Leopard (*Panthera pardus pardus* (Linnaeus)): *R. senegalensis*, *R. simpsoni**, *R. sulcatus*
Lion (*Panthera leo* (Linnaeus)): (in Zoo) *Am. variegatum**
Domestic cat (*Felis catus* Linnaeus): *Hae. leachi* group. (Oppong), *Hae. spinulosa* (Walker & Koney, 1999)

Family Herpestidae
Marsh mongoose (*Atilax paludinosus* (G. [Baron] Cuvier)): *R. sulcatus**, *Amblyomma* immatures
White-tailed mongoose (*Ichneumia albicauda* (G. [Baron] Cuvier)): *Hae. parmata**

Family Viverridae
African civet (*Civettictis civetta* (Schreber)): *Hae. parmata*, *Hae. leachi* group, *I. aulacodi*, *I. cumulatimpunctatus*, *I. moreli**, *I. muniensis*, *I. oldi*, *I. rasus*, *R. simpsoni*, *R. ziemanni*, *Haemaphysalis*, *Ixodes* and *Rhipicephalus* immatures (includes records for two Palm civets (*Nandinia binotata* (Gray))

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