

Ticks (Acari: Ixodida) of the genus *Haemaphysalis* Koch, 1844 in Senegal: a review of host associations, chorology, and identification

Massamba Sylla^{a,b}, Mady Ndiaye^b, Marc Souris^c, Jean-Paul Gonzalez^d

^a UR 178 : Conditions et Territoires d'Émergence des Maladies CTEM, Institut de Recherches pour le Développement, Centre IRD de Hann, B.P. 1386, C. P. 18 524, Dakar, Sénégal.

^b Unité d'Entomologie, de Bactériologie, de Virologie, Département de Biologie Animale, Faculté des Sciences et Techniques, Université Cheikh Anta DIOP, BP 5005 Dakar, Sénégal.

^c UR 178 CTEM, IRD, UMR Unité des Virus Emergents (UVE : Aix-Marseille Univ - IRD 190 - Inserm 1207-IHU Méditerranée Infection), Marseille, France.

^d UR 178 CTEM, IRD, Montpellier, France; Center of Excellence for Emerging & Zoonotic Animal Diseases (CEEZAD), 1800 Kimball Ave, KSU Office Park – CEEZAD Suite 130, Manhattan, KS, USA.

ABSTRACT

The *Haemaphysalis* genus (Acari, Ixodidae) in Senegal is reviewed. This embodies a summary of specimens collected from vertebrate hosts over three decades. 454 collections were performed over this period (408 from mammals and 46 from birds), representing a total of 5752 ticks in different developmental stages. Seven *Haemaphysalis* spp. were collected, identified, and inventoried including: *H. (Kaiseriana) rugosa*, *H. (Ornithophysalis) hoodi*, *H. (Rhipistoma) houyi*, as well as four other species belonging to the *leachi* group, namely *H. (Rhipistoma) leachi*, *H. (Rh.) moreli*, *H. (Rh.) muhsamae* and *H. (Rh.) spinulosa*. Vertebrate hosts of *Haemaphysalis* species were identified and listed in different ecological zones of Senegal. An identification key of the haemaphysalids of Senegal is proposed, which is also applicable to the haemaphysalid fauna of the Occidental sub-region of the Afrotropical zoogeographical region. The role of these species as potential vectors of zoonotic diseases in Senegal is also discussed.

Keywords *Haemaphysalis*; hosts; distribution; diagnosis; Ixodidae; vectors; West Africa

Zoobank <http://zoobank.org/2C4DABA4-796F-42F6-8E0E-25712CC53E93>

Introduction

The genus *Haemaphysalis* Koch, 1844 belongs to the *Ixodidae* family (*Hyalomma* sub-family). Haemaphysalid ticks are characterized by a scutum without ornamentation, a distinctive feature among ixodid ticks of the *Metastratiata* group. These eyeless and inornate ticks lack adanal and subanal plates in males, while females have two short spurs of unequal length on coxa 1. Some other notable characteristics include: short palpi, usually conical with a large palpal segment 2 extending laterally beyond the basis capituli, at least two times longer than segment 1; short mouthparts; a large rear-facing spur on trochanter I; festoons are also present on the posterior margin. *Haemaphysalis* spp. have a three-host life cycle, are mostly associated with wild animals, but sometimes infest livestock (Morel, 2003). Few studies have been carried out on the *Haemaphysalis* genus so far, and those performed mostly focused on their economic importance to livestock in Eurasia, Africa, Australia, and New Zealand (Levin, 2016), with less emphasis on their diversity and role as potential vectors and reservoirs of human and animal pathogens. Indeed, some adaptive changes in haemaphysaline behavior such as a shift from wild deer and antelope to domestic cattle, sheep and goats have been noticed (Levin, 2016),

Received 21 December 2017
Accepted 05 November 2018
Published 16 November 2018

Corresponding author
Massamba Sylla:
massylla19@gmail.com

Academic editor
Karen McCoy

DOI
[10.24349/acarologia/20184297](https://doi.org/10.24349/acarologia/20184297)

© Copyright
Sylla M. *et al.*

Distributed under
Creative Commons CC-BY 4.0



How to cite this article Sylla M. *et al.* (2018), Ticks (Acari: Ixodida) of the genus *Haemaphysalis* Koch, 1844 in Senegal: a review of host associations, chorology, and identification. *Acarologia* 58(4): 928-945; DOI [10.24349/acarologia/20184297](https://doi.org/10.24349/acarologia/20184297)

implying a potential for the emergence of pathogens associated with wild populations into the peridomestic environment within livestock.

Research was performed on hard ticks (i.e. Ixodids) infesting domestic livestock and wild animals in Senegal in order to establish a list of all ixodid ticks found in Senegal (Sylla *et al.*, 2007; 2008). The knowledge previously acquired on the *Haemaphysalis* genus includes: the description of immature stages of *Haemaphysalis rugosa* (Camicas, 1978); revisiting the taxonomy of the *H. leachi* group, with the description of *H. moreli* (Camicas *et al.*, 1972); the delineation of the *aciculifer* group from the *rugosa* group (Hoogstraal and El Kammah, 1972; Camicas, 1978). More recently, Apanaskevich *et al.* (2007) screened many collections of *Haemaphysalis*, previously identified as *Haemaphysalis (Rhipistoma) leachi*, and compared them with typed *H. (Rh.) leachi* specimens from North Africa and the holotype specimen of *Haemaphysalis (Rhipistoma) elliptica*, concluding that many of the Southern and East African ticks previously identified as *H. (Rh.) leachi* were misdiagnosed and are actually *H. (Rh.) elliptica*.

The present study reviews *Haemaphysalis* species known to occur in different geographic areas of Senegal and describes features of their specific diagnosis, their host associations and their chorology.

Materials and methods

Most of the data presented here originate from a collection currently held at the laboratory of Medical Zoology, Research Institute for Development (IRD, Mbour Centre, Senegal). This collection has been continuously enriched by different research projects including: research conducted on birds, wild and domestic mammals during the Crimean-Congo Hemorrhagic Fever (CCHF) program (1987-1993) (Camicas *et al.*, 1990); a project on climatic change and health (Action Thematique Interdisciplinaire, 2003-2004) focusing on tick inventories and the impact of climatic change on their geographical distribution and associated risk of CCHF emergence (Wilson *et al.*, 1990). For these studies, rodents were caught in different geographical areas of Senegal, and ticks were removed from the hosts and preserved in a 70% ethanol solution for further study. More recently, the EDEN project (European Commission Project on “Emerging Diseases in a Changing European Environment: <http://www.eden-fp6project.net>, 2004-2007) included an investigation of West Nile virus ecology leading to bird trapping and tick collection in the Djoudj National Park of Birds (16°25'N, 16°18'W, Saint Louis Department, Saint Louis Region) and Barkedji (15°17'N, 14°52'W, Linguere Department, Louga Region).

Study sites and tick collections have been presented in detail elsewhere (Sylla *et al.*, 2004; 2007; 2008). Tick collections were mapped at the scale of the squared degree including the locality where each tick sample was collected. Maps were generated using SavGIS software (IRD, www.savgis.org). Geographical position of each locality was given by the gazetteer of Senegal (Board on Geographic Names, 1965, Dpt. of the Interior, Washington, D.C., 20240, 1965, IV + 194 pp.) or by using a GPSMAP® 62S (Garmin Inc. Wichita KS).

Haemaphysalis species diagnosis followed an in-house identification key adapted to the ixodid fauna of the Occidental sub-region of the Afrotropical Region (Matthysse and Colbo, 1987A; Elbl and Anastos, 1966) that follows the systematic terminology of Camicas and Morel (Camicas and Morel, 1977; Camicas *et al.*, 1998; Morel, 2003). Features pointed out by Apanaskevich *et al.* (2007) for the diagnosis of the *H. (Rh.) leachi* group are considered in this study. Vertebrate host terminologies follow Walker (1999a and b) and Wilson and Reeder (1992) for mammals and Cabot *et al.* (1992A and B) for birds.

Results

A total of 7 *Haemaphysalis* species, including 3 species of *Haemaphysalis* stricto sensu (*Haemaphysalis (Kaiseriana) rugosa* Santos Dias, 1956; *Haemaphysalis (Ornithophysalis)*

Table 1 Association of *Haemaphysalis* ticks with their known class of vertebrate hosts in Senegal. The number of records per species is given in brackets. % = the percentage of individuals within each life stage for a given species and host class. Total immature = Larvae+Nymph, Total mature = Male+Female.

Tick species	Class of Mammalia				Class of Aves				Total collected per species
	Total Immature L+N	%	Total Mature M+F	%	Total Immature L+N	%	Total Mature M+F	%	
<i>H. (Kaiseriana) rugosa</i> (12)	41	89.1	5	10.9	0	0	0	0	46
<i>H. (Ornithophysalis) hoodi</i> (41)	0	0	0	0	41	69.50	18	30.50	59
<i>H. (Rhipistoma) houyi</i> (143)	730	33.4	1457	66.6	0	0	0	0	2187
<i>H. (Rhipistoma) leachi</i> (203)	1012	33.3	2010	66.2	15	0.5	1	0.0	3038
<i>H. (Rhipistoma) moreli</i> (52)	3	0.7	415	99.3	0	0	0	0	418
<i>H. (Rhipistoma) muhsamae</i> (1)	0	0	1	100	0	0	0	0	1
<i>H. (Rhipistoma) spinulosa</i> (3)	3	100	0	0	0	0	0	0	3
Total ticks collected/life stage	1789	31.5	3888	68.5	56	74.7	19	25.3	
Total ticks collected/class (455)	5677 (98.7%)				75 (1.3%)				5752

hoodi Warburton & Nuttall, 1909; *Haemaphysalis (Rhipistoma) houyi* Nuttall & Warburton, 1915) and four species of the *Haemaphysalis leachi* group (*Haemaphysalis (Rhipistoma) leachi* Audouin, 1826; *Haemaphysalis (Rhipistoma) moreli* Camicas, Hoogstraal & El Kammah, 1972; *Haemaphysalis (Rhipistoma) muhsamae* Santos Dias, 1954; *Haemaphysalis (Rhipistoma) spinulosa* Neumann, 1906), were collected from mammals and birds in Senegal (Table 1).

***Haemaphysalis (Kaiseriana) rugosa* Santos Dias, 1956**

The African antelope spurred-rugose haemaphysalid, was only recorded from mammals (Table 2). The first specimens were collected from wild bovid, mongoose and civet in the Niokolo Koba National Park, NKNP (13°N, 13°W, Tambacounda Reg.) in 1971 and recorded as *Haemaphysalis aciculifer* Warburton, 1913 by Morel (1956), re-identified later by Hoogstraal and El Kammah (1972) as *H. (Ka.) rugosa*. This species has also been recorded from Kedougou (12°33'N, 12°11'W, Kedougou Department, Kedougou Region), Kolda (12°53'N, 14°57'W, Kolda Dpt., Kolda Reg.), and Sangalkam (14°47'N, 17°13'W, Dakar Dpt., Dakar Reg.) (Figure 1).

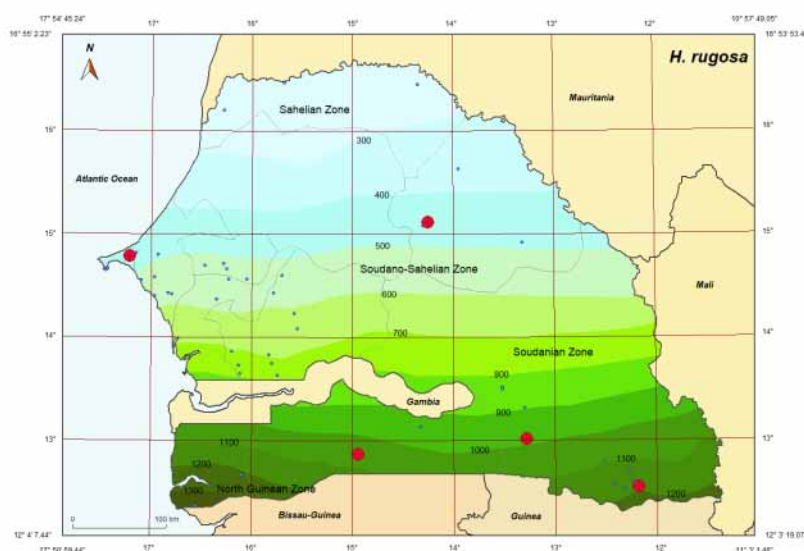


Figure 1 Collecting sites of *Haemaphysalis (Kaiseriana) rugosa* indicated in red; blue dots show localization of all other collection sites.

***Haemaphysalis (Ornithophysalis) hoodi* Warburton & Nuttall, 1909**

Haemaphysalis (Ornithophysalis) hoodi infested birds only (Table 3). Several collection points were obtained for this species throughout Senegal: Gorom (14°49'N, 17°09'W, Dakar Reg.); Sangalkam (14°47'N, 17°13'W, Rufisque Dpt., Dakar Reg.); Saboya (13°39'N, 16°07'W, Nioro Dpt., Kaolack Reg.); Bandia (14°35'N, 17°01'W, Mbour Dpt., Thies Reg.); Kedougou (12°33'N, 12°11'W, Kedougou Dpt., Kedougou Reg.); Kaffrine (14°05'N, 15°33'W, Kaffrine Dpt., Kaffrine Reg.); Missira (13°31'N, 13°31'W, Tambacounda Dpt., Tambacounda Reg.); Kolda (12°53'N, 14°57'W, Kolda Dpt., Kolda Reg.) (Figure 2).

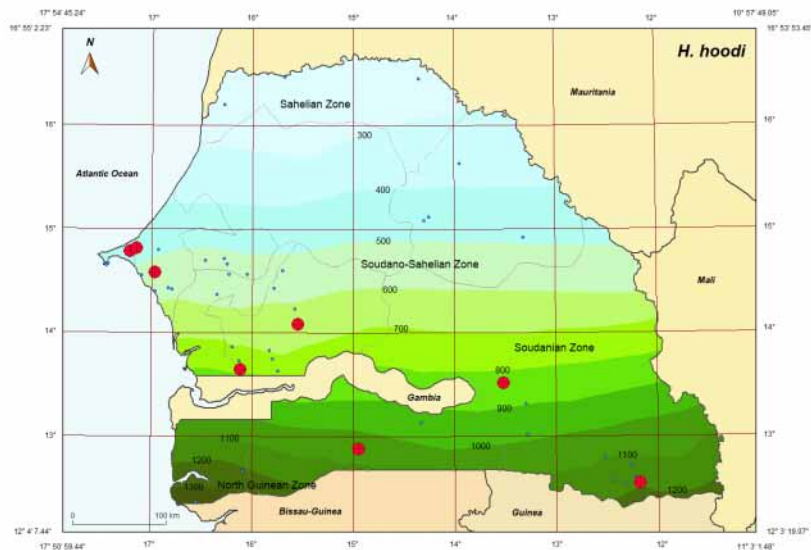


Figure 2 Collecting sites of *Haemaphysalis (Ornithophysalis) hoodi* indicated in red; blue dots show localization of all other collection sites.

***Haemaphysalis (Rhipistoma) houyi* Nuttall & Warburton, 1915**

Haemaphysalis (Rhipistoma) houyi was exclusively collected from the African Ground Squirrel, *Xerus erythropus* (Desmarest, 1817) (Mammalia, Rodentia, Sciuridae) (Table 4). Records of this African tick in Senegal are from several locations: Bandia Forest reserve (14°35'N, 17°01'W, Mbour Dpt., Thies Reg.); Saboya Forest reserve (13°39'N, 16°07'W, Nioro-du-Rip Dpt., Kaolack Reg.); 10km North of Kedougou (12°33'N, 12°11'W, Kedougou Dpt., Kedougou Reg.); Santhiaba Mandjak (12°22'N, 16°33'W, Ziguinchor Dpt., Casamance Reg.); National Park of Basse Casamance, NPBC (12°N, 16°W, Oussouye Dpt., Casamance Reg.); Fadiga (12°33'N, 12°12'W, Kedougou Dpt., Kedougou Reg.); from the area between Sare Dioulde and Sinthian Koundara (13°27'N, 14°20'W, Velingara Dpt., Kolda Reg.) (Figure 3).

***Haemaphysalis leachi* group Camicas, Hoogstraal & El Kammah, 1972**

Haemaphysalis (Rhipistoma) leachi Audouin, 1826: 203 collections were obtained from wild animals including 5 from birds (Table 5) and 198 from mammals (Table 6). At the pre-imaginal stages, it is associated with Carnivores of the Herpestidae and Viverridae families. Immatures are also frequently collected from Insectivora species. In Senegal, the yellow dog-tick, *H. leachi*, has been recorded from: Bandia Forest reserve (14°35'N, 17°01'W, Mbour Dpt., Thies Reg.); Richard-Toll (16°28'N, 15°41'W, Saint-Louis Dpt., Saint Louis Reg.); Bode, Podor (16°27'N, 14°21'W, Podor Dpt., Saint Louis Reg.); Savoigne (16°12'N, 16°17'W, Saint-Louis Dpt., Saint Louis Reg.); Kedougou (12°33'N, 12°11'W, Kedougou Dpt., Kedougou Reg.).

Table 2 Hosts of *Haemaphysalis (Kaiseriana) rugosa* in Senegal. The number of records per species is given in brackets. Total immature = Larvae+Nymph, Total mature = Male+Female.

Order	Host		Stage collected					
	Family	Scientific name Common name	Larva	Nymph	Total Immature (Im)	Male	Female	Total Mature (M)
Artiodactyla (3)	Bovidae (3)	<i>Ourebia ourebi</i> (1) Oribi	0	0	0	1	0	1
		<i>Redunca redunca</i> (1) Reedbuck	0	0	0	1	0	1
		<i>Tragelaphus scriptus</i> (1) Bushbuck	0	0	0	1	0	1
		Total per stage	0	0	0	3	0	3
		Total (Im+M)				3		
	Total	Mammalia, Artiodactyla (3)			3			
	Carnivora (7)	Herpestidae (2)	<i>Herpestes ichneumon</i> (1) African mongoose	0	0	0	1	0
<i>Ichneumia albicauda</i> (1) White-tailed mongoose			1	0	1	0	0	0
Total per stage			1	0	1	1	0	1
Total (Im+M)					2			
Viverridae (5)		<i>Civettictis civetta</i> (1) African civet	0	0	0	1	0	1
		<i>Genetta pardina</i> (1) Forest genet	0	1	1	0	0	0
		<i>Pseudogenetta villiersi</i> (3) Villiers' genet	30	4	34	0	0	0
	Total per stage	30	5	35	1	0	1	
Total (Im+M)				36				
Total	Mammalia, Carnivora (7)			38				
Lagomorpha (1)	Leporidae (1)	<i>Lepus crawshayi</i> (1) Crawshay's hare	0	1	1	0	0	0
		Total per stage	0	1	1	0	0	0
	Total (Im+M)				1			
Total	Mammalia, Lagomorpha (1)			1				
Rodentia (1)	Muridae (1)	<i>Gerbillus sp.</i> (1) Pygmy gerbil	4	0	4	0	0	0
		Total per stage	4	0	4	0	0	0
	Total (Im+M)				4			
Total	Mammalia, Rodentia (1)			4				
General Total	Mammalia (12)			46				

Table 3 Hosts of *Haemaphysalis (Ornithophysalis) hoodi* in Senegal. The number of records per species is given in brackets. Total immature = L+N, Total mature = Male+Female.

Order	Host		Stage collected					Total Mature (M)
	Family	Scientific name Common name	Larva	Nymph	Immature (Im)	Male	Female	
Coraciiforma (7) (=Coraciiforma)	Bucerotidae (6)	<i>Tockus erythrorhynchus</i> (6) Red-billed hornbill	7	0	7	7	1	8
		Coraciidae (1)	<i>Coracias cyanogaster</i> (1) Blue-bellied roller	2	1	3	0	0
	Total per stage		9	1	10	7	1	8
	Total (Im+M)					18		
Total	Aves, Coraciiforma (7)					18		
Cuculiforma (15)	Cuculidae (15)	<i>Centropus senegalensis</i> (15) Senegal coucal	6	8	14	0	0	0
		Total per stage		6	8	14	0	0
	Total (Im+M)					14		
	Aves, Cuculiforma (15)					14		
Galliforma (9)	Phasianidae (9)	<i>Francolinus bicalcaratus</i> (7) Double spurred francolin	6	5	11	1	0	1
		Total per stage	<i>Gallus gallus domesticus</i> (1) Domestic chicken	1	0	1	0	0
	<i>Numida meleagris galeata</i> (1) Helmeted guineafowl		2	0	2	0	0	0
	Total (Im+M)		9	5	14	1	0	1
	Aves, Galliforma (9)					15		
	Passeriforma (10)	Corvidae (1)	<i>Ptilostomus afer</i> (1) Piapiac	1	1	2	0	0
Motacillidae (1)		<i>Macronyx croceus</i> (1) Yellow-throated long claw	0	0	0	0	1	1
Ploceidae (2)		<i>Bubalornis albirostris</i> (2) White-billed buffalo-weaver	0	0	0	1	2	3
		Strunidae (6)	<i>Lamprotornis caudatus</i> (6) Long-tailed glossy starling	0	1	1	1	4
Total per stage			1	2	3	2	7	9
Total (Im+M)					12			
Aves, Passeriforma (10)					12			
General Total	Aves (41)					59		

Ultimately, Villiers (1955) reported it in Dakar (14°40'N, 17°26'W, Dakar Dpt., Dakar Reg.) from the Golden jackal, *Canis aureus* (1♂, December 13, 1946, Institut Fondamental d'Afrique Noire, IFAN), the Serval, *Felis serval* (8♂♂ 3♀♀, October 1945, IFAN) and, the White-tailed mongoose, *Ichneumia albicauda* (2♂♂ 1♀, June 1947, IFAN). Moreover, the yellow dog-tick has been also collected and identified from an extended variety of hosts in Senegal including: the African hedgehog, *Atelerix albiventris* in Bel-Air, Dakar (2♂♂, March 1948, IFAN), in Thiaroye, Dakar (1♂, February, 1955, IFAN); the Serval, *Felis serval* (2♂♂, June 1946, IFAN) in Bignona (12°47'N, 16°14'W, Bignona Dpt., Casamance Reg.); (10♂♂, 3♀♀, May 18, 1956) in Sandiara (14°25'N, 16°48'W, Mbour Dpt., Thies Reg.); the Domestic cat, *Felis catus* (2♀♀, January 4, 1956) in Hann, Dakar (Morel, 1958; 1961); in Sangalkam (14°47'N, 17°13'W, Dakar Dpt., Dakar Reg.) (2♀♀, January 14, 1956); in Popenguine Forest reserve (14°34'N, 17°05'W, Mbour Dpt., Thies Reg) (1♀, January 2, 1956); the Common genet, *Genetta genetta senegalensis* (2♂♂, April 29, 1955) in Nioro-du-Rip (13°45'N, 15°48'W, Nioro Dpt., Kaolack

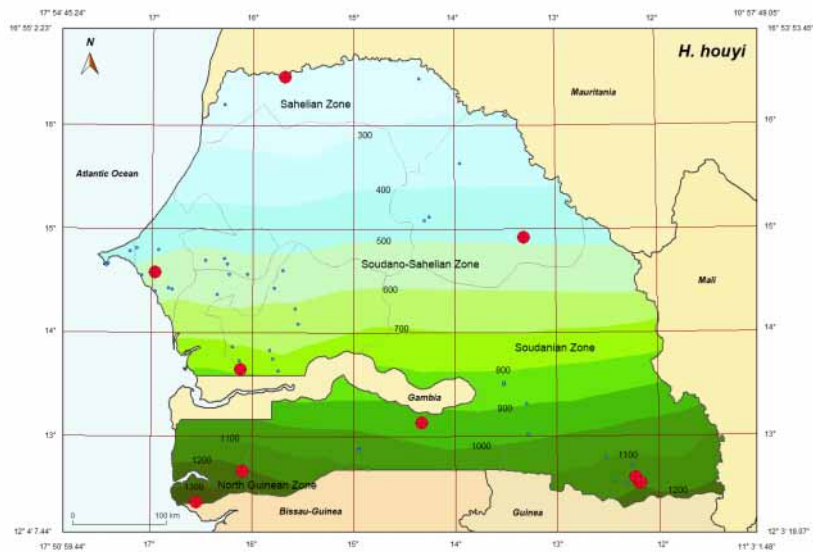


Figure 3 Collecting sites of *Haemaphysalis (Rhipistoma) houyi* indicated in red; blue dots show localization of all other collection sites.

Reg); Missira (13°31'N, 13°31'N; Tambacounda Dpt., Tambacounda Reg.) (1♂, August 28, 1948, IFAN), Richard-Toll (16°28'N, 15°41'W, Saint-Louis Dpt., Saint Louis Reg.) (2♂♂ 1♀, September 24, 1948, IFAN); Kidira (14°27'N, 12°13'W; Kidira Dpt., Tambacounda Reg.); the African civet, *Civettictis civetta* (1♂, 1♀, August 30, 1954) in Tambacounda (13°46'N, 13°39'N; Tambacounda Dpt., Tambacounda Reg.); the domestic dog, *Canis familiaris* (1♀, October 1947, Dakar); the African giant rat, *Cricetomys gambianus* (7NN, 3LL in June 19, 1956, Dakar); Morel (1956) collected *H. leachi* in the NKNP from the Side-striped jackal, *Canis adustus* (2♂♂, September 1955; 1♂, December 6, 1955); African civet, *Civettictis civetta* (8♂♂, 5♀♀, September 1955, 3♂♂, February, 1956); African mongoose, *Herpestes ichneumon* (4♂♂, February 1956, 7♂♂, 3♀♀); White-tailed mongoose, *Ichneumia albicauda* (September 12, 1955); Bushbuck *Tragelaphus scriptus scriptus* (1♀, September 1955); Oribi, *Ourebia ourebi* (4♂♂, 1♀, September 1955). Morel (1961) recorded it again in the NKNP (13°2'N, 13°17'N; Tambacounda Dpt., Tambacounda Reg.) from *Panthera pardus* (1♂ 1♀, March 1955); African wild cat, *Felis libyca* (1♀, March 25, 1957); Villiers' genet, *Pseudogenetta*

Table 4 Hosts of *Haemaphysalis houyi* in Senegal. The number of records per species is given in brackets. Total immature = L+N, Total mature = Male+Female.

Order	Host		Stage collected					Total
	Family	Scientific name Common name	Larva	Nymph	Immature (Im)	Male	Female	
Rodentia (143)	Sciuridae (143)	<i>Xerus erythropus</i> (143)	195	535	730	1164	293	1457
		African ground squirrel						
	Total per stage		195	535	730	1164	293	1457
	Total (Im+M)					2187		
Mammalia, Rodentia					2187			
General Total		Mammalia				2187		

Table 5 Avian hosts of *Haemaphysalis (Rhipistoma) leachi* in Senegal. The number of records per species is given in brackets. Total immature = L+N, Total mature = Male+Female.

Order	Family	Scientific name Common name	Stage collected					Total Mature (M)
			Larva	Nymph	Immature (Im)	Male	Female	
Cuculiforma (4)	Cuculidae	<i>Centropus senegalensis</i> (4) Senegal coucal	10	5	15	0	0	0
		Total per stage	10	5	15	0	0	0
	Total (Im+M)				15			
Total	Aves, Cuculiforma (4)					15		
Passeriforma (1)	Muscicapidae	<i>Myrmecocichla aethiops</i> (1) Northern anteatater chat	0	0	0	0	1	1
		Total per stage	0	0	0	0	1	1
	Total (Im+M)				1			
Total	Aves, Strigiforma (1)					1		
General Total	Aves (5)					16		

villiersi (1♂, March 25, 1955). It was also collected from a Domestic dog (1♀, June 7, 1959) in Fann, Dakar; Common genet, *Genetta g. senegalensis* (3♂♂, 2♀♀, September 28, 1959) in Thiaroye, Dakar; Mbaouane, Kayar (14°53'N, 17°07'W, Tivaouane Dpt., Thies Reg.); *Civettictis civetta* (3♂♂, March, 16 1963) in Kolda (12°53'N, 14°57'W, Kolda Dpt., Kolda Reg.), Bandafassi (12°32'N, 12°19'W, Kedougou Dpt., Kedougou Reg.) in August 2006, and *Pseudogenetta villiersi* (12♂♂, 8♀♀, January 6, 1964; 2♀♀ January, 10, 1964) (Figure 4). Ultimately, the species was recorded by flagging or hand picking *in natura* (1♀, June 23, 1962 in Diender near Tanma lake (15♂♂, 8♀♀, June 12, 1962), and also from different unidentified rodents spp. (2NN, March 2, 1962; 4LL, July 25, 1962; 32LL, 2NN, February 25, 1963).

***Haemaphysalis (Rhipistoma) moreli* Camicas, Hoogstraal & El Kammah, 1972**

Haemaphysalis (Rhipistoma) moreli has been only collected from mammals in Senegal (Table 7). Collection reference sites are as follow: Ngohé (14°34'N, 16°3'W; Diourbel Dpt., Diourbel Reg.); Bao Bolon River (13°38'N, 15°45'W, Niore du Rip Dpt., Kaolack Reg.); Bandia Forest reserve; Saboya Forest reserve; Dialakoto (13°19'N, 13°18'W, Tambacounda Dpt., Tambacounda Reg.); Bandafassi (12°32'N, 12°19'W, Kedougou Dpt., Kedougou Reg.). It was collected from *Civettictis civetta* in August 2006; between Thies and Bambey on the road; in Kedougou (12°33'N, 12°11'W, Kedougou Dpt., Kedougou Reg.); Sandiara (14°25'N, 16°48'W, Mbour Dpt., Thies Reg.); Etiess (12°34'N, 12°26'W, Salemata Dpt., Kedougou Reg.); Dakar-Yoff (14°45'N, 17°28'W, Dakar Dpt., Dakar Reg.) (Figure 4).

***Haemaphysalis (Rhipistoma) muhsamae* Santos Dias, 1954**

Haemaphysalis (Rhipistoma) muhsamae is typically a parasite of carnivores of the Mustelidae and Viverridae families. It was confused for a long time with *H. leachi*, which shares the same hosts and the same geographical distribution. A specimen collected from the zorilla or Striped polecat, *Ictonyx striatus* (Carnivora, Mustelidae) in Hann, Dakar is deposited (1♂, August 5, 1939, IFAN) (Figure 4). Although not abundant in the collection, several records from Senegal are attributed to this species. Those are from Diourbel (14°40'N, 16°15'W, Diourbel Dpt., Diourbel Reg.); Mahekor Forest reserve; Bao Bolon (13°38'N, 15°45'W, Niore du Rip Dpt., Kaolack Reg.); Kassas Forest reserve (14°14'N, 15°35'W, Kaffrine Dpt., Kaffrine Reg.); Saboya Forest reserve (13°39'N, 16°07'W, Niore-du-Rip Dpt., Kaolack Reg.); Bandia Forest reserve (14°35'N, 17°01'W, Mbour Dpt., Thies Reg.); Ngoyé = Ngohé (14°34'N, 16°3'W; Diourbel Dpt., Diourbel Reg.); Dialakoto (13°19'N, 13°18'W, Tambacounda Dpt.,

Table 6 Mammalian hosts of *Haemaphysalis (Rhipistoma) leachi* in Senegal. The number of records per species is given in brackets. Total immature = L+N, Total mature = Male+Female.

Order	Host		Stage collected					Total Mature (M)	
	Family	Scientific name	Larva	Nymph	Immature (Im)	Male	Female		
Carnivora (131)	Canidae (17)	<i>Canis adustus</i> (1)	0	2	2	126	87	213	
		<i>Canis aureus</i> (9)	0	0	0	34	17	51	
		<i>Canis lupus familiaris</i> (1)	0	0	0	0	1	1	
		<i>Vulpes pallida</i> (6)	0	0	0	20	12	32	
	Total per stage			0	0	2	180	117	297
	Total (Im+M)			299					
	Felidae (21)	<i>Felis catus</i> (5)	0	1	1	9	0	9	
		<i>Felis lybica</i> (10)	0	4	4	133	57	190	
		<i>Felis serval</i> (2)	0	0	0	1	0	1	
		<i>Felis sylvestrus</i> (2)	0	0	0	2	4	6	
		<i>Panthera leo</i> (1)	8	0	8	0	0	0	
		<i>Panthera pardus</i> (1)	0	0	0	1	0	1	
	Total per stage			8	5	13	146	61	207
Total (Im+M)			220						
Herpestidae (40)	<i>Atilax paludinosus</i> (9)	0	1	1	96	33	129		
	<i>Herpestes ichneumon</i> (3)	0	4	4	22	1	23		
	<i>Ichneumia albicauda</i> (25)	358	50	408	194	78	272		
	<i>Mungos gambianus</i> (1)	0	0	0	2	0	2		
	<i>Mungos mungo</i> (1)	0	0	0	10	2	12		
	<i>Mongoose, ind</i> (1)	0	0	0	0	1	1		
	Total per stage			358	55	413	324	115	439
Total (Im+M)			1062						
Mustelidae (1)	<i>Ictonyx striatus</i> (1)	0	0	0	1	0	1		
Total per stage			0	0	0	1	0	1	
Total (Im+M)			1						
Viverridae (53)	<i>Civettictis civetta</i> (9)	0	0	0	70	31	101		
	<i>Genetta g. senegalensis</i> (14)	0	0	0	63	33	96		
	<i>Pseudogenetta villiersi</i> (30)	91	2	93	147	68	215		
Total per stage			91	2	93	280	132	412	
Total (Im+M)			505						
Total	Mammalia, Carnivora (130)		2085						
Artiodactyla (1)	Suidae (1)	<i>Potamochoerus porcus</i> (1)	0	1	1	0	0	0	
	Total per stage			0	1	1	0	0	0
Total (Im+M)			1						
Total	Mammalia, Artiodactyla (1)		1						
Insectivora (52)	Erinaceidae (52)	<i>Aterix albiventris</i> (52)	284	177	461	467	180	647	
	Total per stage			284	177	461	467	180	647
Total (Im+M)			1108						
Total	Mammalia, Insectivora (53)		1108						
Lagomorpha (2)	Leporidae (2)	<i>Lepus aegyptius</i> (1)	0	0	0	0	1	1	
		<i>Lepus crawshayi</i> (1)	2	0	2	0	0	0	
Total per stage			2	0	2	0	1	1	
Total (Im+M)			3						
Total	Mammalia, Lagomorpha (2)		3						
Rodentia (12)	Muridae (11)	<i>Arvicanthis niloticus</i> (2)	1	1	2	0	0	0	
		<i>Mastomys erythroleucus</i> (4)	13	9	22	0	0	0	
		<i>Mastomys huberti</i> (1)	1	0	1	0	0	0	
		<i>Rattus rattus</i> (1)	0	1	1	0	0	0	
		<i>Tatera guinea</i> (1)	1	0	1	0	0	0	
		<i>Rodent's burrow</i> (2)	2	0	0	2	3	5	
	Total per stage			17	11	27	2	3	5
Total (Im+M)			32						
Hystricidae (1)	<i>Hystrix cristata</i> (1)	0	0	0	0	1	1		
Total per stage			0	0	0	0	1	1	
Total (Im+M)			1						
Total	Mammalia, Rodentia (12)		33						
General Total	Mammalia (198)		3022						

Table 7 Hosts of *Haemaphysalis moreli* in Senegal. The number of records per species is given in brackets. Total immature = L+N, Total mature = Male+Female.

Order	Host		Stage collected					Total Mature (M)
	Family	Scientific name	Larva	Nymph	Immature (Im)	Male	Female	
Carnivora (47)	Canidae (1)	<i>Vulpes pallida</i> (1) Pale fox	0	1	0	0	0	0
		Total per stage	0	0	1	0	0	0
		Total (Im+M)				1		
	Felidae (4)	<i>Felis catus</i> (1) Domestic cat	0	0	0	0	0	1
		<i>Felis libyca</i> (3) African wild cat	0	0	0	3	4	7
		Total per stage	0	0	0	3	4	7
		Total (Im+M)				7		
	Herpestidae (1)	<i>Atilax paludinosus</i> (1) Marsh mongoose	0	0	0	1	0	1
		Total per stage	0	0	0	1	0	1
	Total (Im+M)				1			
	Viverridae (41)	<i>Civettictis civetta</i> (5) African civet	0	0	0	8	5	13
		<i>Genetta g. senegalensis</i> (13) Common genet	0	2	2	68	44	112
		<i>Genetta pardina</i> (1) Forest genet	0	0	0	17	17	34
		<i>Genetta tigrina</i> (1) Large-spotted genet	0	0	0	5	10	15
		<i>Pseudogenetta villiersi</i> (21) Villiers' genet	0	0	0	164	57	221
		Total per stage	0	2	2	262	133	395
		Total (Im+M)				397		
Total	Mammalia, Carnivora (47)							
Insectivora (5)	Erinaceidae (5)	<i>Atelerix albiventris</i> (5) African hedgehog	0	0	0	11	1	12
		Total per stage	0	0	0	11	1	12
	Total (Im+M)				12			
Total	Mammalia, Insectivora (5)					12		
General Total	Mammalia (52)					418		

Tambacounda Reg.); Bambey, CNRA (14°N, 16°W, Thiès Dpt., Thies Reg.); Almadies, Dakar; on the road to Thies-Bambey; on the road Bambey-Fatick-Mbour (14°N, 16°W, Kaolack and Thies Regs.); on the road Bandia-Fatick; Sandiara-Khombole; Dakar; on the road to Fatick-Mbour; Sandiara-Mbour; Mbour; on the road to Bandia-Mbour; Kedougou; Sandiara (14°25'N, 16°48'W, Mbour Dpt., Thies Reg.); Thies; Louly; Baria Forest reserve (13°37'N, 16°13'W, Nioro du Rip Dpt., Kaolack Reg.); Sidioli (12°43'N, 12°16'W, Kedougou Dpt., Kedougou Reg.); on the road to Kedougou-Mako (12°N, 12°W, Kedougou Dpt., Tambacounda Reg.); and Bandafassi (12°32'N, 12°19'W, Kedougou Dpt., Kedougou Reg.).

***Haemaphysalis (Rhipistoma) spinulosa* Neumann, 1906**

Haemaphysalis (Rhipistoma) spinulosa typically from the Oriental subarea, is known in this subarea as *Haemaphysalis ethiopica* Santos Dias, 1958 (Hussein and Mustafa, 1983) (Table 8). Numerous collection references are attributed to *H. spinulosa* in Senegal: Bandia Forest

Table 8 Hosts of *Haemaphysalis (Rhipistoma) spinulosa* in Senegal. The number of records per species is given in brackets. Total immature = L+N, Total mature = Male+Female.

Order	Host		Stage collected					
	Family	Scientific name	Larva	Nymph	Total			Total
		Common name			Immature (Im)	Male	Female	Mature (M)
Carnivora (2)	Herpestidae (1)	<i>Ichneumia albicauda</i> (1)	1	0	1	0	0	0
		White-tailed mongoose						
	Viverridae (1)	<i>Genetta g. senegalensis</i> (1)	0	1	1	0	0	0
		Common genet						
	Total (Im+M)		1	1	2	0	0	0
	Mammalia, Carnivora (2)					2		
Rodentia (1)	Cricetomyidae (1)	<i>Cricetomys gambianus</i> (1)	0	1	1	0	0	0
		African giant pouched rat						
	Total (Im+M)					1		
	Mammalia, Rodentia (1)					1		
General Total	Mammalia (3)					3		

reserve (14°35'N, 17°01'W, Mbour Dpt., Thies Reg.); Saboya Forest reserve; (13°39'N, 16°07'W, Niore-du-Rip Dpt., Kaolack Reg.); on the road to Sandiara-MBour; Kedougou; Bandafassi (12°32'N, 12°19'W, Kedougou Dpt., Kedougou Reg.); Sidioli (Figure 4).

Determination key of Western African *Haemaphysalis* spp. (Senegal, Mauritania, Mali, Gambia, Guinea, Bissau Guinea, Burkina Faso, Ivory Coast)

Males

1. Coxa IV with a long internal lanceolate spur, longer than the width of the coxa itself, conscutum with dense to moderate punctuations, parasite of ruminants *H. rugosa*
 — Coxa IV with an internal spur shorter than the width of the coxa itself, or absent 2
2. Palpal segment III with a strong retrograde dorsal spur, prominent; lateral grooves very short, almost reaching half of the conscutum; parasite of antelopes *H. parvata*
 — Palpal segment III without retrograde dorsal spur 3
3. Basidorsal margin of palpi in a straight line, forming a right angle with the inner axis of the palps. Basis capituli rectangular. Scutum proximately large with marked punctuations; parasite of birds *H. hoodi*
 — Basidorsal margin of palps drawing a retrograde spur more or less developed, or forming an angle. Parasite of mammals 4
4. Coxal spurs moderately long, prominent, each one reaching almost the next coxa. Trochanter I with a strong ventral spur, other trochanters with moderately short spurs, not strong nor pointed. Tarsi short and strong, bluntly pointed. Scutum broadly elongate with few scattered, shallow punctuations. Lateral grooves long reaching the level of intercoxal space II + III, Parasite of *Xerus erythropus* *H. houyi*
 — Trochanter I without ventral spur. Coxae with a short pointed spur on at least two pairs. Palpal profile laterally straight or very slightly concave; palpal segment 3 ventrally bearing a fine retrograde spur, pointed, relatively long. Common on carnivores, rare on other animals 5

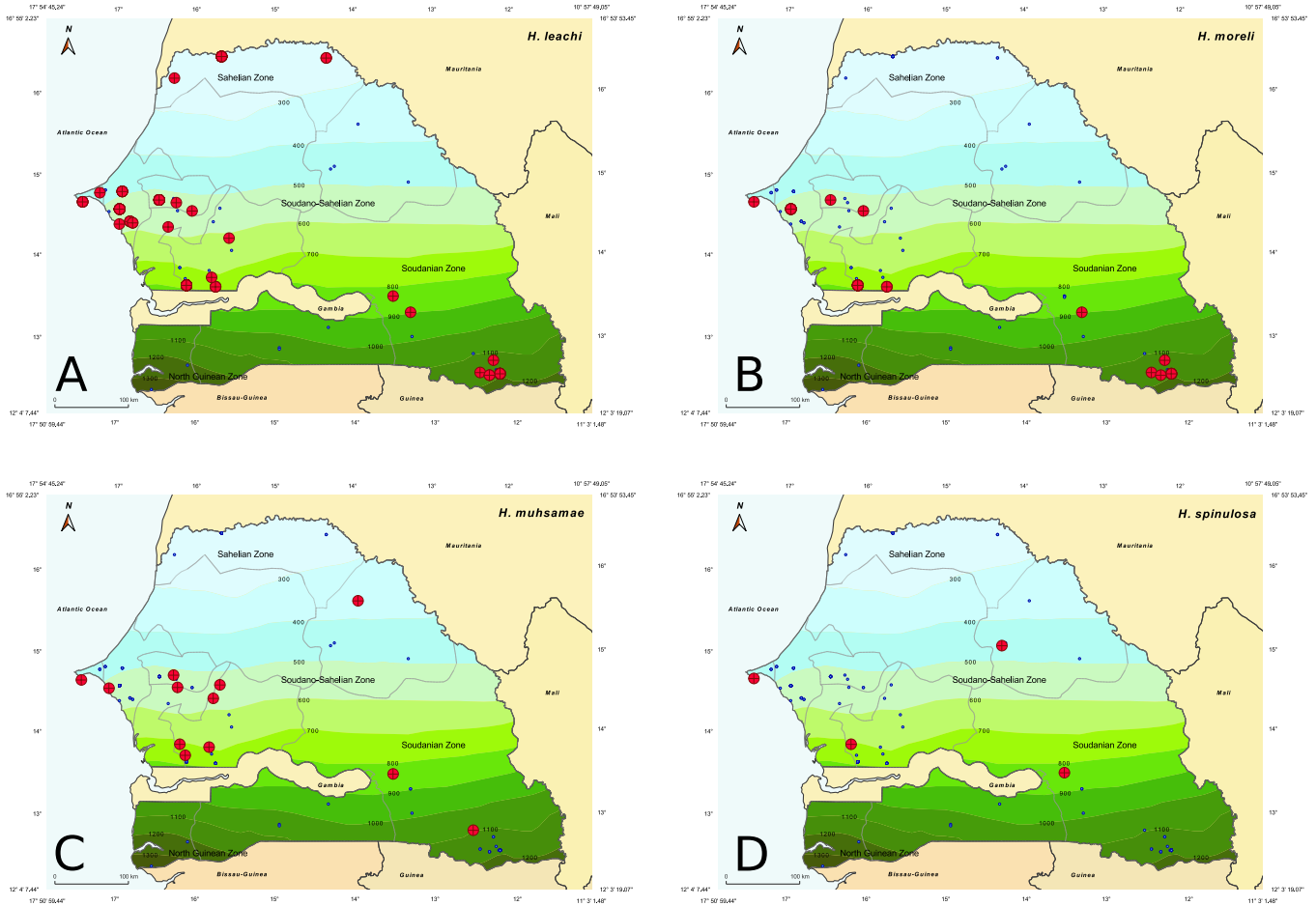


Figure 4 Collecting sites of *Haemaphysalis* of the *leachi* group indicated in red; blue dots show localization of all other collection sites: A – *Haemaphysalis (Rhipistoma) leachi*; B – *Haemaphysalis (Rhipistoma) moreli*; C – *Haemaphysalis (Rhipistoma) muhsamae*; D – *Haemaphysalis (Rhipistoma) spinulosa*.

- 5. Conscutum broadly rounded posteriorly showing dense, deep separated punctuations, of moderate size, basis capituli external margin diverging, ventral spur of palpal segment 3 straight, more acutely pointed. *H. punctaleachi*
 — Conscutum shagreened, showing numerous dense, deep contiguous punctuations, of small to moderate size 6
- 6. Moderate-sized punctuations, lateral grooves enclosing only the first festoon, cornua triangular, palpal segment 2 interno-dorsal margin strongly bulging. *H. moreli*
 — Punctuations clearly separated, moderate to high in number, tiny to moderate in size. Hypostomal formula varying from 4/4 to 6/6. 7
- 7. Hypostomal formula 5/5 or 6/6. Large species measuring 3.5-4.0 mm in length over 1.7-1.9 mm in width. Nine to eleven festoons. Lateral groove enclosing one festoon or sometimes partially two *H. paraleachi*
 — Hypostomal formula 4/4, smaller tick species, 1.3-3.8 over 0.8-1.9 mm. Eleven festoons, lateral groove enclosing only one festoon 8
- 8. Small ticks, 1.3-2.2 mm length over 0.8-1.2 mm in width. Eleven festoons. Large scutum: 1.6 times longer than width. Coxal spurs small; tarsi II and IV short, robust, bumped and

bluntly pointed. Lateral margins of basis capituli largely diverging forward, cornua short and wide. Lateral groove enclosing 1 festoon. (Common on small carnivores) *H. spinulosa*
 — Small to moderately thin species, 1.88-2.97 mm length for 0.82-1.29 mm width. Eleven festoons. Coxal spurs long, distinctly overlapping the next coxal margin, tarsi II-IV elongated, gradually. Conscutum narrow and slightly convex, 2 times longer than wide and smoothly rounded posteriorly. Cervical pits narrow, deep and converging, cervical grooves short, shallow, slightly visible and diverging. Lateral margins of basis capituli slightly diverging forward, cornua sharp, elongated and triangular. Lateral grooves conspicuous, distinct, extending ¼ scutal length and enclosing 2 to 3 festoons (Common on small and large carnivores)
 *H. leachi*

Females

1. Basidorsal margin of palpal segment 3 with a spur or markedly oblique anteriorly. Scutum approximately as long as wide 2
 — Basidorsal margin of palpal segment 3 horizontal, approximately perpendicular to the long axis of the palp, without angle nor spur 3

2. Palpal segment 3 with a postero-dorsal spur. Basis capituli with small cornua. Scutum wider than long. Coxa I with a small spur overlapping the external basal margin, but without a postero-internal spur *H. parmata*
 — No postero-dorsal spur on palpal segment 3. Basis capituli with sharp cornua. Scutum rough or shagreened with dense and numerous punctuations of moderate size, as long as wide, or slightly longer than width. Short spur at the internal basal angle of coxa 1 *H. rugosa*

3. Basidorsal margin of palps straight, without any marked angle or spur. Basis capituli almost straight laterally, vestigial cornua. Scutum almost as long as wide. Parasites of birds
 *H. hoodi*
 — Basidorsal margin of palps with an angle or bearing a spur. Lateral margins of basis capituli diverging. Cornua moderate to well-developed. Parasites of mammals 4

4. Palps with a basiventral spur, fine and moderately long; dorsal margin distinctly pointed sublaterally; segment 3 with a ventral fine spur, elongated and pointed. Each coxa with a well-developed spur (spur-like ridge) not overlapping the trochanter's margin; tarsi bluntly pointed, short, well-developed and sometimes bumped. Claws as long as tarsi. Scutum slightly longer than wide, broadly rounded posteriorly; few widely scattered shallow punctuations (20-30), essentially located in the anterior part, posterior margin broad and regularly rounded. Basiventral margin of palpi with a strong median spur. Parasite of the Geoffroy's ground squirrel (*Xerus erythropus*) *H. houyi*
 — Combination of characters different. Palpi generally bearing a conspicuous basal spur, dorsal or ventral, palpal segment 3 with a retrograde ventral spur, elongated, pointed and narrow; lateral profile straight or slightly curved, rarely concave. Basis capituli with strong cornua (generally not parasite of the Geoffroy's ground squirrel, common on carnivores, but rare on other mammals) 5

5. Basiventral margin of palpal segment 2 with a strong, pointed spur. Few scutal punctuations *H. spinulosa*
 — Species of small to moderate size, 1.17-1.70 mm long and 0.66-0.96 mm wide. Lateral margins of scutum slightly diverging anteriorly, converging posteriorly giving a bluntly rounded aspect. Cervical grooves narrow arcs extending 2/3 of total scutal length. Numerous scutal punctuations. Palpi broadly salient (*leachi* type), basiventral margin of palpal segment 2 without a strong, pointed spur. Spur reduced to a short obtuse angle looking like a curve 6

6. Conspicuous spurs on all coxae. Long and pointed cornua *H. leachi*
 — Small coxal spurs. Short and rounded cornua 7
7. Hypostomal formula 5/5 or 5.5/5.5. Large elongate *Haemaphysaline* (3.59-3.93 mm long and 1.77-1.88 mm wide for unengorged specimens). External margins of basis capituli diverging slightly anteriorly. Tarsi II to IV bluntly pointed *H. paraleachi*
 — Hypostomal formula 4/4. Moderate size *Haemaphysalis*, from 2.1-3.0 mm long and 1.0-1.6 mm wide. Basis capituli diverging anteriorly. Tarsi II to IV curving proximally 8
8. Basis capituli approximately 2.8 times longer than wide. Spurs on coxae II and III reduced to small protrusions. Basiventral margin of palpal segment 2 with a small, narrow indentation, nearly at mid-width of the posterodorsal segment *H. moreli*
 — Basis capituli approximately 2.1 times wider than long. Conspicuous spurs on coxae II and III. Basiventral margin of palpal segment 2 with a large emargination, approximately near the mi-width of the segment, showing a sinuous aspect. *H. punctaleachi*

Discussion

Haemaphysalis rugosa infests antelopes and buffalo as principal hosts for adults, but the species can also be found on carnivores and livestock. In Senegal, immature stages were collected on Carnivores of the Herpestidae and Viverridae families, adult stages were recorded from wild Bovidae including bushbuck, reedbuck and oribi (Table 2). Immature ticks are known to feed on civets, genets, rodents, and hares (Camicas, 1978; Hoogstraal and Kim, 1985; Yeoman and Walker, 1967, Hoogstraal and El Kammah, 1972). It is a typical species of wet savannas. *H. rugosa* has been recorded from Senegal in the south and the West Coast of Dakar. It is known in Burkina Faso, Ivory Coast, Ghana, Benin, Uganda, Sudan, Central African Republic (north-eastern), and Democratic Republic of Congo (north-eastern).

Haemaphysalis hoodi preferentially parasitizes ground feeding birds at all stages. All stages were collected from different bird orders including: Cuculiforma, Galliforma and Passeriforma, in the sudanian and sudano-guinean domains of Senegal (Table 3). Hoogstraal (1958) also recorded it from domestic chicken, *Gallus domesticus*. *Haemaphysalis hoodi* is known from sub-Saharan Africa and Morocco (Walker, 1991).

Haemaphysalis houyi is characterized by strict host-parasite specificity, only known to infest the African Ground Squirrel, *X. erythropus*. It is recorded in all geographic domains of Senegal, due to the wide distribution of its hosts. This species is also reported to occur in Mali, Burkina Faso, Ivory Coast, Ghana, Chad, Central African Republic, Cameroon, Sudan, Ethiopia, Uganda, and Kenya (Hoogstraal and Kim, 1985; Ntiamoa-Baidu *et al.*, 2004).

Haemaphysalis spinulosa adults appear to feed on various small and medium-sized carnivores, as well as hedgehogs. In Senegal, immature stages are found on Carnivora of the families Herpestidae and Viverridae; they can also feed on small mammals as rodents (Table 7). This species has been recorded in sub-Saharan Africa and Yemen (Hussein and Mustafa, 1983; 1985; Hoogstraal and Kim, 1985; Walker, 1991).

Haemaphysalis parmata was not recorded in Senegal, but is known from Ivory Coast, in the same biogeographic Occidental subarea, and is considered in the proposed key.

Haemaphysalis (Rhipistoma) leachi group (subgroup *leachi*) includes five species of which three are described from the Occidental subarea of the Afrotropical region: 1) *H. (Rh.) leachi* (Audouin, 1826) was originally described in Egypt from grass-rats, *Arvicanthis niloticus* (Desmarest, 1822), and the Long-eared hedgehog, *Hemiechinus auritus aegyptius* E. Geoffroy, 1803 and their resting habitats (Hoogstraal, 1958). Adults can also feed on jungle cat, *Felis chaus nilotica* de Winton, 1898; the common fox, *Vulpes vulpes aegyptica* (Sonnini, 1816) and the wolf jackal, *Canis aureus lupaster* Hemprich and Ehrenberg, 1833; 2) *H. (Rh.) moreli*

Camicas, Hoogstraal & El Kammah, 1972 was described from genets, civets and also recorded on Felid carnivores, including lions, leopards, servals, hyaena, jackals, foxes, domestic cats and dogs of Western and Eastern Africa; 3) *Haemaphysalis (Rhipistoma) paraleachi* Camicas, Hoogstraal & El Kammah, 1983 parasitizing small and medium-sized carnivores as civets in Central Africa; *Haemaphysalis (Rhipistoma) punctaleachi* Camicas, Hoogstraal & El Kammah, 1973 is also found on civets, leopard, jackal and antelope of West African Guinean forests, and *H. (Rhipistoma) elliptica* (Koch, 1844) being known only from Austral and Oriental Africa. For comparative purposes, *H. punctaleachi* is included in the key.

The *Haemaphysalis (Rh.) spinulosa* subgroup incorporated four species, namely *H. (Rh.) muhsamae* Santos Dias, 1954, *H. (Rh.) spinulosa* Neumann, 1906; *Haemaphysalis (Rhipistoma) norvali* Hoogstraal & Wassef, 1983 and *Haemaphysalis (Rhipistoma) subterra* Hoogstraal, El Kammah & Camicas, 1992 also from Austral and Oriental Africa.

The taxonomic status of *H. (Rh.) elliptica* and *H. (Rh.) leachi* was updated by Apanaskevich *et al.* (2007); they also gave some collection references of *H. (Rh.) leachi* from the same carnivore hosts as in our study in Senegal [*Leptailurus serval* = *Felis (Leptailurus) serval*, *Felis silvestris lybica* and *Civettictis civetta*], but a taxonomic revision of the whole *H. (Rh.) leachi* group, including host associations and distribution ranges, is still needed. In West Africa, *H. (Rh.) leachi* infests a wide range of carnivore hosts including the domestic dog, domestic cat, lion, *Panthera leo* Linnaeus, 1758; and leopard, *Panthera pardus* Linnaeus, 1758 as adults, and immature stages are found on a variety of rodent species. Adults of both species have been recorded in several collections obtained from a single host.

Although the haemaphysalid tick species of Senegal described here are not known to carry or vector pathogens of medical importance, detailed studies are currently lacking. Several other species from the Amblyommid family (i.e. *Amblyomma*, *Rhipicephalus* and *Hyalomma* spp.) have been found infected with a variety of viruses in Senegal including: Bandia, Bhanja, Cocksackie B4, CCHF, Dugbe, Jos, Koutango, NDelle, Ndumu, Somone, Wad Medani or Ngoye (Anonyme, 1998; Grard *et al.*, 2006). Moreover, other *Haemaphysalis* spp. are known worldwide as pathogen carriers: protozoan parasites *stricto sensu* [e.g.: *Babesia gibsoni*, *B. bigemina*, *B. ovata*, *Toxoplasma gondi*, *Hepatozoon canis* (Dubey and Beattie, 1988; Zhou *et al.*, 2016); *Theileria orientalis*, *T. recondita*, *T. mutans* (Fujisaki *et al.*, 1994, Alani and Herbert, 1998; Gao *et al.*, 2008); bacteria as *Rickettsia heilongjiangensis*, *R. japonica*, *R. siberica*, *Coxiella burnetii* (Jongejan and Uilenberg, 2004, Liu *et al.*, 2014); *Anaplasma phagocytophilum*, *Borrelia burgdorferi*, *Francisella tularensis* ssp., *Mycobacterium*, *Sphingomonas* spp., *Pseudomonas* spp., *Wolbachia* spp., *Brucella melitensis* (Nosek, 1971b; Raoult and Roux, 1997; Gyuranecz *et al.*, 2011)]. A wide range of viruses (e.g.: Bhanja, Barur, Crimean-Congo hemorrhagic fever, Ganjam, Kaisodi, Kyasanur Forest Disease, New Minto, Powassan encephalitis, Louping-ill, Russian spring-summer encephalitis, Burana, Sawgrass, Silverwater or Tribec) are also carried by *Haemaphysalis* ticks (Work *et al.*, 1957; Work and Trapido, 1957; Trapido *et al.*, 1959; Anonyme, 1964; Bhatt *et al.*, 1966; Dandawate and Shah., 1969; Dandawate *et al.*, 1969; Boshell *et al.*, 1970; Rajagopalan *et al.*, 1970; Nosek *et al.*, 1971a and b; Vesenjok-Hirjan *et al.*, 1977; Pavlov *et al.*, 1978; Pattnaik, 2006; Yadaw *et al.*, 2011; Holbrook, 2012; Lasecka and Baron, 2013; Lvov *et al.*, 2014; Mourya *et al.*, 2014; Walker *et al.*, 2015; Yang *et al.*, 2016). Again, other newly identified emerging viruses have been isolated from *Haemaphysalids* including: the Tick-borne zoonosis with severe fever and thrombocytopenia syndrome virus (Liu *et al.*, 2014; Fujisaki *et al.*, 1994; Jongejan and Uilenberg, 2004); the Huaiyangshan virus (Yu *et al.*, 2011; Zhang *et al.*, 2011; Zhang *et al.*, 2012; Kuhn *et al.*, 2016), the Khasan virus from Maritime Territory China, as well as the Kwatta virus (Rhabdoviridae) and the Burana virus (Khoo *et al.*, 2016).

Ultimately, the haemaphysalid tick fauna of Senegal requires more in depth investigations to complete our knowledge, including biological, morphological and taxonomic studies and an evaluation of the transmission risk of pathogens. We postulate, for example, that the entomological surveillance conducted on hemaphysalid ticks in Senegal is too limited to declare these species of no risk and thus merit further investigation. Indeed *H. leachi*, the

yellow or African dog tick, is found in tropical and southern Africa and can transmit canine and feline babesiosis, Mediterranean spotted fever, Q-fever, and Boutonneuse fever (Sonenshine, 1992b; Khoo *et al.*, 2016). With respect to climate change, migration and commercial trade, understanding the health risks associated with tick-borne pathogens appears of public health importance in the geographic domains where haemaphysalid tick circulate. Indeed, their relative abundance, their seasonality, their geographical extension need to be assessed; the involvement of the *Haemaphysalis* genus in pathogen transmission may be underestimated.

Acknowledgements

The authors thank the anonymous reviewers for invaluable corrections. This work is dedicated to the late Dr. Jean-Louis Camicas who reviewed the earlier version of the manuscript.

References

- Alani A. J., Herbert I. V. 1998. Morphology and transmission of *Theileria recondita* (Theileriidae: Sporozoa) isolated from *Haemaphysalis punctata* from North Wales. *Vet. Parasitol.*, 28: 283-291. doi:10.1016/0304-4017(88)90075-1
- Anonyme 1964. Indian Council of Medical Research. Kyasanur Forest Disease 1957-1964. Cambridge Print. Works Delhi, 1 volume, 30 pages.
- Anonyme 1998. Rapport annuel, Centre collaborateur OMS de référence et de recherche sur les arbovirus. Institut Pasteur de Dakar, 141 pp.
- Apanaskevich D. A., Horak I. G., Camicas J. L. 2007. Redescription of *Haemaphysalis (Rhipistoma) elliptica* (Koch, 1844), an old taxon of the *Haemaphysalis (Rhipistoma) leachi* group from East and southern Africa, and of *Haemaphysalis (Rhipistoma) leachi* (Audouin, 1826) (Ixodida, Ixodidae). *Onderstepoort J. Vet. Res.*, 74:181-208. doi:10.4102/ojvr.v74i3.122
- Bhatt P. N., Work T. H., Varma M. G. R., Trapido H., Murthy N. D. P., Rodrigues F. M. 1966. Isolation of Kyasanur forest disease from infected humans and monkeys of Shimoga District, Mysore State. *Indian J. Med. Sci.*, 20: 316-320.
- Board on Geographic Names. 1965. Senegal. Names for places and features in Senegal. U.S. Govt. Printing Office, Division of Geography, Department of the Interior, Washington, D. C., pp. IV + 194.
- Boshell J., Desai P. K., Dandawate C. N., Goverdhan M. K. 1970. Isolation of Ganjam virus from ticks *Haemaphysalis intermedia*. *Indian J. Med. Res.*, 58: 561-562.
- Cabot J., Carboneras C., Elliott A., Folch A., del Hoyo J., de Juana E., Llimona F., Martínez I., Martínez-Vilalta A., Matheu E., Motis A., Orta J. 1992A. Handbook of the birds of the world. Volume 1 Ostrich to Ducks. Lynx eds, Barcelona, Spain. 696 pp.
- Cabot J., Carboneras C., Elliott A., Folch A., del Hoyo J., de Juana E., Llimona F., Martínez I., Martínez-Vilalta A., Matheu E., Motis A., Orta J. 1992B. Handbook of the birds of the world. Volume 2 New world Vultures to Guinea-fowls. Lynx eds. 638 pp.
- Camicas J. L., Hoogstraal H., El Kammah K. M. 1972. Notes on African *Haemaphysalis* ticks. VIII. *H. (Rhipistoma) moreli* sp. n., a carnivore parasite of the *H. (R.) leachi* group (Ixodoidea: Ixodidae). *J. Parasitol.*, 58: 1185-1196. doi:10.2307/3278163
- Camicas J. L., Morel P. C. 1977. Position systématique et classification des tiques. (Acarida: Ixodida). *Acarologia*, 18 (3): 410-420.
- Camicas J. L. 1978. Contribution à l'étude des tiques du Sénégal (Acarida : Ixodida) 1. Description des stades préimaginales d'*Haemaphysalis (Kaiseriana) rugosa* Santos Dias, 1956. *Cah. ORSTOM, Ser. Ent. Med. Parasitol.*, XVI (1): 23-28.
- Camicas J. L., Wilson M. L., Cornet J. P., Digoutte J. P., Calvo M-A., Adam F., Gonzalez J. P. 1990. Ecology of Ticks as potential vectors of Crimean-Congo hemorrhagic fever virus in Senegal: epidemiological implications. *Arch. Virol.*, [Suppl. 1]: 303-322.
- Camicas J. L., Hervy J. P., Adam F., Morel P. C. 1998. Les tiques du monde nomenclature, stades décrits, hôtes, répartition. ORSTOM eds. Paris, 240 pp.
- Dandawate C. N., Shah K. V. 1969. Ganjam virus: A new arbovirus isolated from ticks *Haemaphysalis intermedia* Warburton and Nuttall, 1909 in Orissa, India. *Indian J. Med. Res.*, 57: 799-804.
- Dandawate C. N., Work T. H., Webb J. K., Shah K. V. 1969. Isolation of Ganjam virus from a human case of febrile illness: A report of a laboratory infection and serological survey of human sera from three different states of India. *Indian J. Med. Res.*, 57:975-982.
- Dubey J. P., Beattie C. P. 1988. *Toxoplasmosis of Animals and Man*. Boca Raton: CRC Press Inc.
- Elbl A., Anastos G. 1966. Ixodid ticks (Acarina: Ixodoidea) of Central Africa. *Ann. Mus. Roy. Afrique Centrale Tervuren*. Volume IV. Genus *Aponomma* Neumann, 1899, *Boophilus* Curtis, 1891, *Dermacentor* Koch, 1844, *Haemaphysalis* Koch, 1844, *Hyalomma* Koch, 1844 and *Rhipicentor* Nuttall & Warburton, 1908 pp.
- Fujisaki K., Kawazu S., Kamio T. 1994. The taxonomy of the bovine *Theileria* spp. *Parasitol. Today*, 10: 31-33. doi:10.1016/0169-4758(94)90355-7
- Gao J., Luo J., Fan R., Fingerle V., Guan G., Liu Z., Li Y., Zhao H., Ma M., Liu J., Liu A., Ren Q., Dang Z., Sugimoto C., Yin H. 2008. Cloning and characterization of a cDNA clone encoding

- calreticulin from *Haemaphysalis qinghaiensis* (Acari: Ixodidae). *Parasitol. Res.*, 102(4): 737-746. doi:10.1007/s00436-007-0826-y
- Grard G., Lemasson J. J., Sylla M., Dubot A., Cook S., Molez J. F., Pourrut X., Charrel R., Gonzalez J. P., Munderloh U. Holmes E. C., De Lamballarie X. 2006. Ngoye virus: a novel evolutionary lineage within the genus *Flavivirus*. *J. Genet.*, 87(11): 3273-3277. doi:10.1099/vir.0.82071-0
- Gyurancz M., Rigo K., Dan A., Foldvari G., Makrai L., Denes B., Fodor L., Majoros G., Tirjak L., Erdelyi K. 2011.- Investigation of the Ecology of *Francisella tularensis* During an Inter-Epizootic Period.- *Vector-Borne Zoon. Dis.*, 11 (8): 1031-1035. doi:10.1089/vbz.2010.0091
- Holbrook M. R. 2012.. Kyasanur forest disease. -*Antivir. Res.*, 96(3): 353-362. doi:10.1016/j.antiviral.2012.10.005
- Hoogstraal H. 1958.. Notes on African *Haemaphysalis* ticks. IV. Description of Egyptian populations of the yellow dog-tick, *H. leachii leachii* (Audouin, 1827) (Ixodoidea, Ixodidae). *J. Parasitol.*, 44: 548-558. doi:10.2307/3274429
- Hoogstraal H., El Kammah K. M. 1972. Notes on African *Haemaphysalis* ticks. X. *H. (Kaiseriana) aciculifer* Warburton and *H. (Ka.) rugosa* Santos Dias, the African representatives of the *spinigera* subgroup (Ixodoidea: Ixodidae). *J. Parasitol.*, 960-978. doi:10.2307/3286594
- Hoogstraal H., Kim K. C. 1985.. Chapter 10. Tick and mammal coevolution with emphasis on *Haemaphysalis*. Pp. 505-568, in *Coevolution of parasitic arthropods and mammals.. Pr. Ke Chung Kim eds. John Wiley and sons, New York.*
- Hussein H. S., Mustafa B. E. 1983. *Haemaphysalis (Rhipistoma) spinulosa* Neumann, 1906: Description of immature stages, adult structural variations, and notes on biology (Ixodoidea: Ixodidae). *J. Parasitol.*, 69 (2): 405-412. doi:10.2307/3281245
- Hussein H. S., Mustafa B. E. 1985. *Haemaphysalis spinulosa* and *Rhipicephalus simus* (Acari: Ixodidae): seasonal abundance of immature stages and host range in the Shambat area, Sudan. *J. Med. Entomol.* 22:72-77. doi:10.1093/jmedent/22.1.72
- Jongejan F., Uilenberg G. 2004. The global importance of ticks. *Parasitol.* 129:S3-S14. doi:10.1017/S0031182004005967
- Kho J. J., Chen F., Kho K. L., Ahmad Shanizza A. I., Lim F. S., Tan K. K., Chang L. Y., AbuBakar S. 2016. Bacterial community in *Haemaphysalis* ticks of domesticated animals from the Orang Asli communities in Malaysia. -*Ticks and Tick-borne Dis.*, 7: 929-937. doi:10.1016/j.ttbdis.2016.04.013
- Kuhn J. H., Wiley M. R., Rodriguez S. E., Bao Y., Prieto K., Travassos da Rosa A. P., Guzman H., Savji N., Ladner J. T., Tesh R. B., Wada J., Jahrling P. B., Bente D. A., Palacios G. 2016.. Genomic Characterization of the genus *Nairovirus* (Family *Bunyaviridae*). *Viruses* 8(6): 164. doi:10.3390/v8060164
- Lasecka L., Baron M. D. 2013. The molecular biology of nairoviruses, an emerging group of tick-borne arboviruses. *Arch. Virol.*, 159: 1249-1265. doi:10.1007/s00705-013-1940-z
- Levin M. L. 2016. Ticks. *The Merck Veterinary Manual*, 11th Edition. S. E. Ajello and M. A. Moses eds. Kenilworth, NJ, Merck Publishing and Merial: 925-942.
- Liu Q., He B., Huang S. Y., Wei F., Zhu X. Q. 2014. Severe fever with thrombocytopenia syndrome, an emerging tick-borne zoonosis. *Lancet Infect. Dis.*, 14:763-772. doi:10.1016/S1473-3099(14)70718-2
- Lvov D. K., Alkhovsky S. V., Shchelkanov M. Yu., Shchetinin A. M., Deryabin P.G., Gitelman A. K., Aristova V. A., Botikov A. G. 2014. Taxonomic status of the Burana virus (BURV) (*Bunyaviridae*, *Nairovirus*, *Tamdy* group) isolated from the ticks *Haemaphysalis punctata* Canestrini & Fanzago, 1877 and *Haem. concinna* Koch, 1844 (Ixodidae, *Haemaphysalinae*) in Kyrgyzstan [in Russian] . *Vopr Virusol.*, 59:10-15.
- Matthysse J. G., Colbo M. H. 1987A. The Ixodid ticks of Uganda, together with species pertinent to Uganda because of their present known distribution. *Entomol. Soc. America, College Park, Maryland, XII + 426pp.*
- Morel P. C. 1956.. Le Parc National du Niokolo-Koba (Premier fascicule). XV – Tiques d’animaux sauvages. *Mémoires de l’Institut Français d’Afrique Noire* N48. IFAN-Dakar. 228-232.
- Morel P. C. 2003. Les tiques d’Afrique et du Bassin méditerranéen, 1350 pp. + Contribution à la connaissance de la distribution des tiques (Acariens, Ixodidae et Amblyommidae) en Ethiopienne continentale. 388 pp. + Annexe cartographique de 62 cartes. CD-Rom, Cirad 2003. Alfort (France) et L.N.R.V. Dakar (Sénégal), manuscrit non publié, 1342 + x pp.
- Mourya D. T., Yadav P. D., Patil D. Y. 2014. Highly infectious tick-borne viral diseases: Kyasanur forest disease and Crimean-Congo haemorrhagic fever in India. *WHO South-East Asia J. Pub. Health.*, 3(1): 8-21.
- Nosek J. Z. 1971a. The ecology, bionomics and behaviour of *Haemaphysalis (Haemaphysalis) concinna* Tick. *Parasitenk.*, 36: 233-241. https://doi:10.1007/BF00348561
- Nosek J. Z. F. 1971b. -The ecology, bionomics, and behaviour of *Haemaphysalis (Aboimisalis) punctata* tick in central Europe. *Parasitenk.*, 37(3): 198-210. https://doi:10.1007/BF0025949.
- Ntiemoa-Baidu Y., Carr-Saunders C., Matthews B. E., Preston P.M., Walker A. R. 2004. 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. *Bull. Ent. Res.*, 94(3): 245-260. doi:10.1079/BER2004302
- Pattnaik P. 2006. Kyasanur forest disease: an epidemiological view in India. *Rev. Med. Virol.*, 16 (3): 151-165. doi:10.1002/rmv.495
- Pavlov P., Rosický B., Hubálek Z., Daniel M., Bárdos V., Minár J., Juricová Z. 1978. Isolation of Bhanja virus from ticks of the genus *Haemaphysalis* in southeast Bulgaria and presence of antibodies in pastured sheep. *Folia Parasitol.*, 25(1): 67-73.
- Rajagopalan P. K., Sreenivasan M. A., Paul S. D. 1970. Isolation of Ganjam virus from the bird tick *Haemaphysalis wellingtoni* Nuttall and Warburton 1907. *Indian J. Med. Res.*, 58: 1195-1196.

- Raoult D., Roux V. 1997. Rickettsioses as paradigms of new or emerging infectious diseases. *Clin. Microbiol. Rev.*, 10(4): 694-719. doi:10.1128/CMR.10.4.694
- Sonenshine D. E. 1992b. *Biology of ticks*. Vol. 2. Oxford University Press, New York, 465 pp.
- Sylla M., Pourrut X., Faye N., Bâ K., Cornet J. P., Camicas J. L. 2004. Argasidae (Acari: Ixodida) parasite of wild and domestic animals in Senegal: 1-Review and distribution. *Acarologia*, 44 (3-4): 137-150.
- Sylla M., Molez J. F., Cornet J. P., Mondet B., Camicas J. L. 2007. Les tiques (Acari : Ixodida) du Sénégal : Fréquence des hôtes répertoriés, dynamique saisonnière et chorologie d'*Amblyomma (Xiphiastor) variegatum* (Fabricius, 1794). *Acarologia*, 47 (1-2): 13-23.
- Sylla M., Molez J. F., Cornet J. P., Camicas J. L. 2008. Impact du changement climatique sur la répartition des tiques au Sénégal et en Mauritanie. *Acarologia*, 48 (3-4) : 137-153.
- Trapido H., Rajagopalan P. K., Work T. H., Varma M. G. 1959. Isolation of Kyasanur Forest disease virus from naturally infected ticks of the genus *Haemaphysalis*. *Indian. J. Med. Res.*, 47:133-138.
- Vesenjak-Hirjan J., Calisher C., Brudnjak Z., Tovornik D., Skrtic N., Lazvick J. S. 1977. Isolation of Bhanja virus from ticks in Yugoslavia. *Am. J. Trop. Med. Hyg.*, 26: 1003-1008. doi:10.4269/ajtmh.1977.26.1003
- Villiers A. 1955.. Notes sur quelques Ixodidae et Argasidae parasites des vertébrés rencontrés en A.O.F. *Bull. IFAN*, 17 (A, 2): 444-454.
- Walker J. B. 1991. A review of the ixodid ticks (Acari, Ixodidae) occurring in southern Africa. *Onderstepoort J. Vet. Res.*, 58:81-105.
- Walker E. P. 1999a. *Mammals of the World*. (2 volumes). (Sixth Edition). Volume I. Baltimore and London. The Johns Hopkins University Press, 836 pp.
- Walker E. P. 1999b. *Mammals of the World*. (2 volumes). (Sixth Edition). Volume II. Baltimore and London. The Johns Hopkins University Press, 1085 pp.
- Walker P. J., Firth C., Widen S. G., Blasdel K. R., Guzman H., Wood T. G., Paradkar P. N., Holmes E. C., Tesh R. B., Vasilakis N. 2015.. Evolution of Genome Size and Complexity in the Rhabdoviridae. *PLOS Pathog.*, 11(2): e1004664. doi:10.1371/journal.ppat.1004664
- Wilson M. L., Gonzalez J. P., LeGuanno B., Cornet J. P., Guillaud M., Calvo M. A., Digoutte J. P., Camicas J. L. 1990. Epidemiology of Crimean-Congo hemorrhagic fever in Senegal: temporal and spatial patterns. Volume 1 of the series *Arch. Virol.*, (Suppl. 1): 323-340.
- Wilson D. E., Reeder D. M. 1992. *Mammal species of the world. A taxonomic and geographic reference*. Second edition, Smithsonian Institution Press. Washington, 1206 pp.
- Work T. H., Trapido H. 1957. Kyasanur forest disease: a new virus disease in India: summary of preliminary report of investigations of the VRC on the epidemic disease affecting forest villagers and wild monkeys of Shimoga district, Mysore State. *Indian J. Med. Sci.*, 11:41-342.
- Work T. H., Trapido H., Murthy D. P., Rao R. L., Bhatt P. N., Kulkarni K. G. 1957. "Kyasanur forest disease. III. A preliminary report on the nature of the infection and clinical manifestations in human beings. *Indian J. Med. Sci.*, 11(8): 619-645.
- Yadav P. D., Vincent M. J., Khristova M., Kale C., Nichol S. T., Mishra A. C., Mourya D. T. 2011. Genomic analysis reveals Nairobi sheep disease virus to be highly diverse and present in both Africa, and in India in the form of the Ganjam virus variant. *Infect. Genet. Evol.*, 11: 1111-1120. doi:10.1016/j.meegid.2011.04.001
- Yang J., Tian Z., Liu Z., Niu Q., Han R., Li Y., Guan G., Liu J., Liu G., Luo J., Yin H. 2016.. Novel spotted fever group rickettsiae in *Haemaphysalis qinghaiensis* ticks from Gansu, Northwest China. *Parasit Vectors* 9:146. https://doi:10.1186/s13071-016-1423-1427.
- Yeoman G. H., Walker J. B. 1967. The ixodid ticks of Tanzania. A study of the zoogeography of the Ixodidae of an east African country. London and Reading: Commonwealth Institute of Entomology. xii + 215 pp.
- Yu X. J., Liang M. F., Zhang S. Y., Liu Y., Li J. D., Sun Y. L., Zhang L., Zhang Q. F., Popov V.L., Li C., Qu J., Li. Q., Zhang Y.P., Hai R., Wu W., Wang Q., Zhan F. X., Wang X. J., Kan B., Wang S. W., Wan K. L., Jing H. Q., Lu J. X., Yin W. W., Zhou H., Guan X. H., Liu J. F., Bi Z. Q., Liu G. H., Ren J., Wang H., Zhao Z., Song J. D., He J. R., Wan T., Zhang J. S., Fu X. P., Sun L. N., Dong X. P., Feng Z. J., Yang W. Z., Hong T., Zhang Y., Walker D. H., Wang Y., Li D. X. 2011. Fever with thrombocytopenia associated with a novel bunyavirus in China. *N. Engl. J. Med.*, 364: 1523-1532. doi:10.1056/NEJMoa1010095
- Zhang Y. Z., Zhou D. J., Xiong Y., Chen X. P., He Y. W., Sun Q., Yu B., Li J., Dai Y. A., Tian J. H., Qin X. C., Jin D., Cui Z., Luo X. L., Li W., Lu S., Wang W., Peng J. S., Guo W. P., Li M. H., Li Z. J., Zhang S., Chen C., Wang Y., deJong M. D., Xu J. 2011.. Hemorrhagic fever caused by a novel tick-borne Bunyavirus in Huaiyangshan, China. *Zhonghua Liu Xing Bing Xue Za Zhi*, 32: 209-220.
- Zhang Y. Z., Zhou D. J., Qin X. C., Tian J. H., Xiong Y., Wang J. B., Chen X. P., Gao D. Y., He Y. W. Jin D., Sun Q., Guo W. P., Wang W., Yu B., Li J., Dai Y. A., Li W., Peng J. S., Zhang G. B., Zhang S., Chen X. M., Wang Y., Li M. H., Lu X., Ye C., de Jong M. D., Xu J. 2012. The ecology, genetic diversity, and phylogeny of Huaiyangshan virus in China. *J. Virol.*, 86: 2864-2868. doi:10.1128/JVI.06192-11
- Zhou Y., Zhang H., Cao J., Gong H., Zhou J. 2016.. Epidemiology of toxoplasmosis: role of the tick *Haemaphysalis longicornis*. *Infect. Dis. Poverty*, 5: 14. doi:10.1186/s40249-016-0106-0

Acarologia

A quarterly journal of acarology, since 1959
Publishing on all aspects of the Acari

All information:



<http://www1.montpellier.inra.fr/CBGP/acarologia/>
acarologia@supagro.fr



**Acarologia is proudly non-profit,
with no page charges and free open access**

Please help us maintain this system by
encouraging your institutes to subscribe to the print version of the journal
and by sending us your high quality research on the Acari.

Subscriptions: Year 2018 (Volume 58): 380 €

<http://www1.montpellier.inra.fr/CBGP/acarologia/subscribe.php>

Previous volumes (2010-2016): 250 € / year (4 issues)

Acarologia, CBGP, CS 30016, 34988 MONTFERRIER-sur-LEZ Cedex, France

The digitalization of Acarologia papers prior to 2000 was supported by Agropolis Fondation under the reference ID 1500-024 through the « Investissements d'avenir » programme (Labex Agro: ANR-10-LABX-0001-01)



Acarologia is under **free license** and distributed under the terms of the Creative Commons-BY-NC-ND which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original author and source are credited.