Geographical Distribution, Host Associations, and Vector Roles of Ticks (Acari: Ixodidae, Argasidae) in Sweden

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ABSTRACT This review covers the geographic distribution and host relationships of the tick species in Sweden. *Ixodes uriae* White, *I. caledonicus* Nuttall, *I. unicavatus* Neumann, *I. arboricola* Schulze & Schlottke, and *I. lividus* Koch are ornithophagous species. *I. trianguliceps* Birula, *I. canisuga* Johnston, *I. hexagonus* Leach, and *Argas vespertilionis* (Latreille) are mammalophagous. *I. ricinus* (L.) and *Haemaphysalis punctata* Canestrini & Fanzago feed on both birds and mammals. All these tick species may be considered to be permanently present in Sweden. *I. persulcatus* Schulze, *Hyalomma marginatum* Koch, and the brown dog tick, *Rhipicephalus sanguineus* (Latreille), may be regarded as not indigenous to Sweden although they may be regularly introduced by spring-migrating birds or imported dogs, respectively. The first European record of the American dog tick, *Dermacentor variabilis* (Say), is reported. There are several records of *Hyalomma aegyptium* (L.) from imported tortoises in Sweden. Excluding other ticks imported on exotic pets and zoo animals, another 13 tick species are listed that may occur, at least occasionally, in Sweden. Because of its wide geographic distribution, great abundance, and wide host range, *I. ricinus* is medically the most important arthropod in northern Europe. *I. ricinus* is common in southern and south-central Sweden and along the coast of northern Sweden and has been recorded from 29 mammal species, 56 bird species, and two species of lizards in Sweden alone. The potential introduction to Sweden of exotic pathogens with infected ticks (e.g., *I. persulcatus* and *H. marginatum* on birds or *Dermacentor* spp. and *R. sanguineus* on mammals) is evident.

KEY WORDS Ixodoidea, hosts, Sweden

TICKS ARE OF PRIMARY IMPORTANCE as vectors of disease agents of animals and are ranked second to mosquitoes as the medically most important group of arthropods. In northern Europe most ticks belong to the family Ixodidae, and a limited number of species belong to Argasidae. The Scandinavian tick fauna and the geographical distribution of the different tick species have been investigated by several scientists. The Swedish tick fauna was studied by Schulze (1930), Arthur (1952), and Brinck et al. (1965, 1967). During the 1970s the late Anders Nilsson carried out extensive ecological investigations on *I. ricinus* (L.) and *I. trianguliceps* Birula. His studies are summarized in Nilsson (1974, 1978, 1988), Brinck-Lindroth et al. (1975), and Nilsson & Lundqvist (1978).

The Danish tick fauna was studied by Schulze (1929), Arthur (1955), and Haarlöv (1962, 1981). Hallas (1978) listed 22 tick species, including ticks imported on zoo and pet animals.

From Iceland three tick species have been recorded: *I. uriae* White (Sellnick 1940, Lindroth et al. 1973), *I. ricinus*, and *I. hexagonus* Leach (Lindroth et al. 1973).

Tambs-Lyche (1943b) published the first survey of Norwegian ticks, in which five species were listed. Later, Mehl (1970, 1979, 1983) summarized the geographical distributions and host associations of Norwegian ticks; by 1983, 11 species of ticks had been recorded in Norway.

In Finland, Schulze et al. (1937) listed three tick species (*I. ricinus, I. nivalis* Rondelli [=*I. trianguliceps*], and *Ceratixodes uriae* Schulze [=*I. uriae*]). Later, Öhman (1961) presented the geographical distribution of *I. ricinus* in Finland. Records of ticks on birds in Finland were published by Nuorteva & Hoogstraal (1963), Ulmanen et al. (1977), and Saikku et al. (1971). Ulmanen (1972) mentioned five species of ticks in the Finnish fauna (*I. ricinus, I. plumbeus* Leach [=*I. lividus* Koch], *I. arboricola* Schulze & Schlottke, *Hyalomma marginatum* Koch, and *I. trianguliceps*), excluding the Finnish record of *I. uriae*

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mentioned by Schulze et al. (1937). Thus, six species of ticks have been recorded from Finland. Extensive studies on ticks and tick-borne diseases, particularly arboviruses, have been carried out in Finland (Saikku & Brummer-Korvenkontio 1973, 1975; Saikku 1974).

Several pathogens of man and other vertebrates are transmitted by ticks. In northern Europe tick-borne diseases include babesiosis, caused by *Babesia divergens* M'Fadyean & Stockman, *B. motasi* Wenyon, and *B. microti* Franca (Tambs-Lyche 1943a, 1959; Wiger 1978, 1979; Wahlgren et al. 1984; Christensson 1989); tularemia, caused by *Francisella tularensis* (McCoy & Chapin) (Olin 1942, Berglund 1965, Pearson 1975, Ljung 1988); Lyme borreliosis, caused by *Borrelia burgdorferi* s.l. Johnson, Schmid, Hyde, Steigerwalt & Brenner (Åsbrink 1985; Stiernstedt 1985; Hovmark et al. 1988; Jaenson 1988, 1991; Jaenson et al. 1989; Gustafson et al. 1990); *Ehrlichia phagocytophila* (Foggie) (Christensson 1989); and several viroses (Tambs-Lyche 1959; Saikku 1974; Saikku & Brummer-Korvenkontio 1975; Traavik & Mehl 1975, 1977; Traavik 1979; Saikku et al. 1980; Mehl & Traavik 1983; Brummer-Korvenkontio et al. 1984; Jaenson 1988) including the Central European form of tick-borne encephalitis (TBE) (von Zeipel et al. 1958; Brinck et al. 1965, 1967; Traavik et al. 1978; Holmgren & Forsgren 1989, 1990 [further refs. in Jaenson 1988]).

In view of the presence of several tick-borne pathogens of man and animals in Sweden and the recent discovery of Lyme borreliosis as an infection of considerable medical importance in Sweden, there is a need to review the scattered data on the geographic distribution and host associations of ticks in Sweden. Thus, the aim of this article is to compile all relevant data on the geographic distribution of Swedish ticks and their host relationships. To illustrate the breadth of host selection and the potential for additional species to appear in Sweden, we have included information on ticks in countries adjacent to Sweden.

Materials and Methods

All records of Swedish ticks available in the authors' institutions and private collections and at The Museum of Natural History in Gothenburg; The National Museum of Natural History in Stockholm; The Zoological Museum, Department of Zoology, Lund University; The Zoological Museum, Department of Zoology, Uppsala University; and The Parasitological Laboratory, National Veterinary Institute, Uppsala, have been studied by us and are included in the data.

During 1989, we placed announcements in several Swedish newspapers; weekly and monthly magazines; and entomological, veterinary, and medical journals in which we asked for ticks from throughout Sweden.

Ornithologists at the bird-ringing stations at Falsterbo, Sundre, Nidingen, Tåkern, Eggegrund, Fjäderägg, and Haparanda Sandskär; at The Department of Zoology, Uppsala University; and amateur bird ringers have provided ticks collected from birds trapped in Sweden during 1990 and 1991. During that period hunters in the Uppsala and Stockholm regions have provided mammal skins, particularly from roe deer (*Capreolus capreolus*), moose (*Alces alces*), badger (*Meles meles*), and hares (*Lepus europaeus, L. timidus*), from which we have collected ticks. In the *Results* section under *New records* we have included records recently published elsewhere (Jaenson & Tälleklint 1992, Tälleklint & Jaenson 1993).

In Tables 3 and 4 under *Previous records,* we have included all literature records of Swedish ticks known to us and considered relevant. However, tick species recorded only from or in association with the importation of zoo animals or exotic pets (mammals, birds, and reptiles) are mentioned only briefly. Under *New records* each numeral denotes the number of host individuals on which the particular stage of tick was recorded. *Total* denotes the number of host individuals with ticks of that particular species.

Abbreviations used for the regional (provincial) divisions of Sweden are shown in Fig. 1. Countries are abbreviated as follows: Be, Belgium; BI, the British Isles; De, Denmark; Es, Estonia; Fi, Finland; Ge, Germany; Ic, Iceland; La, Latvia; Li, Lithuania; Lu, Luxemburg; Ne, The Netherlands; No, Norway; Po, Poland; SPe, St. Petersburg region of Russia; Sw, Sweden.

The following main sources were used to trace records of ticks from countries outside Sweden in northern and western Europe: Pomerantzev (1950), Arthur (1963), Filippova (1966, 1977), USDA (1978), and Kolonin (1981) for distributions covering several countries; Hallas (1978) for Denmark; Sellnick (1940) and Lindroth et al. (1973) for Iceland; Mehl (1983) and Mehl et al. (1984) for Norway; Schulze et al. (1937), Nuorteva & Hoogstraal (1963), Saikku et al. (1971), Ulmanen (1972), and Ulmanen et al. (1977) for Finland; A. Pototski & V. Pool (Sanitary Epidemiological Station, Tallin, Estonia; personal communication) and Anastos (1957) for St. Petersburg Region, Estonia, Latvia, and Lithuania; Lachmajer (1967), Pruszynska (1983), and Siuda (1987) for Poland; Liebisch (1991) for Germany; Bronswijk et al. (1979) for The Netherlands, Belgium, and Luxemburg; and Arthur (1963) and Martyn (1988) for Great Britain. The nomenclature of ticks follows that of Clifford et al. (1973) and Camicas & Morel (1977); nomenclature of mammals and birds follows that of Corbet (1978) and Sveriges Ornitologiska Förening (1990), respectively.

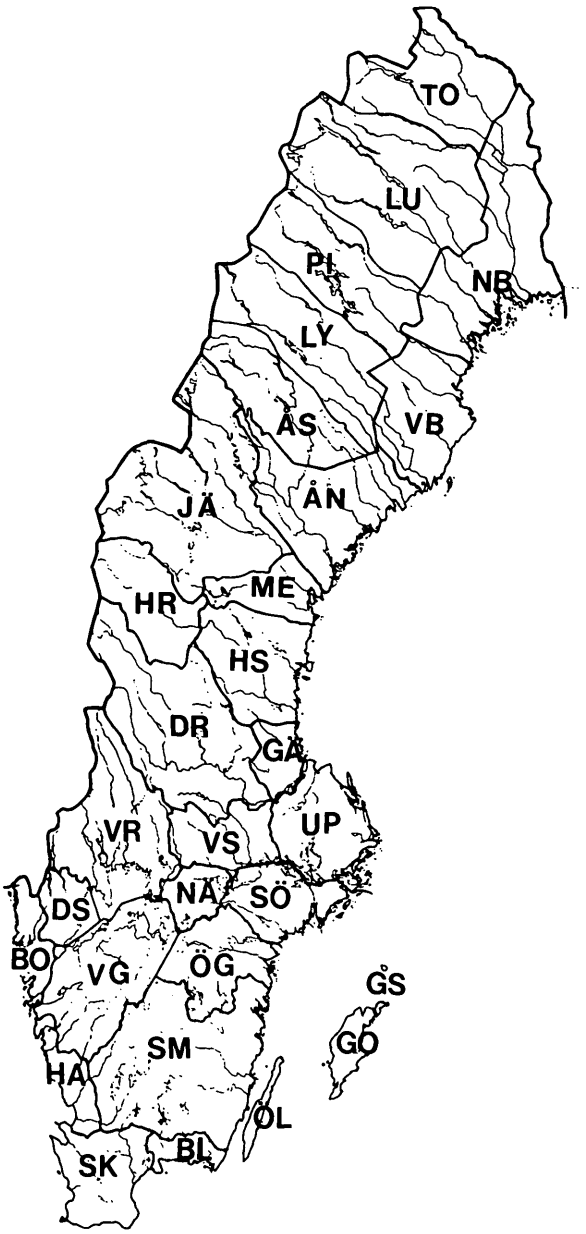

Fig. 1. The provinces (landskap) of Sweden. SK, Skåne; BL, Blekinge; HA, Halland; SM, Småland; ÖL, Öland; GO, Gotland; GS, Gotska Sandön; ÖG, Östergötland; VG, Västergötland; BO, Bohuslän; DS, Dalsland; NÄ, Närke; SÖ, Södermanland; UP, Uppland; VS, Västmanland; VR, Värmland; GÄ, Gästrikland; DR, Dalarna; HS, Hälsingland; HR, Härjedalen; ME, Medelpad; ÅN, Ångermanland; JÄ, Jämtland; VB, Västerbotten; NB, Norrbotten; ÅS, Åsele Lappmark; LY, Lycksele Lappmark; PI, Pite Lappmark; LU, Lule Lappmark; TO, Torne Lappmark.

Results

Tick Species Recorded from Sweden

Ixodes (Exopalpiger) trianguliceps Birula, 1895 (synonyms: *I. tenuirostris* Neumann, 1901; *I. nivalis* Rondelli, 1928). The vole tick, the shrew tick

The general distribution of this European species is from Ireland through most of Europe to Bajkal, Caucasia, and Crimea (Kolonin 1981). The geographical distribution of *I. trianguliceps* in Sweden and northern Europe is given in Tables 1 and 2.

In Sweden *I. trianguliceps* has been recorded from 11 species of shrews and rodents (Table 3). Hosts of *I. trianguliceps* in northern Europe have also been recorded in Denmark (Arthur 1955, Brinck et al. 1984), Norway (Mehl 1983), Finland (Ulmanen 1972), Poland (Pruszynska 1983), and the British Isles (Martyn 1988): *Homo sapiens* (Br), *Erinaceus europaeus* (Br), *Sorex minutus* (De, No, Fi, Po, Br), *S. araneus* (De, No, Fi, Po, Br), *Neomys fodiens* (No, Br), *Crocidura suaveolens* (Br), *Talpa europaea* (Br), *Oryctolagus cuniculus* (Br), *Neosciurus carolinensis* (Br), *Lemmus lemmus* (No), *Myopus schisticolor* (No), *Clethrionomys rutilus* (No), *C. rufocanus* (No), *C. glareolus* (De, No, Fi, Po, Br), *A. terrestris* (No, Fi, Br), *Microtus arvalis* (De, Po), *M. agrestis* (De, No, Fi, Br), *M. oeconomus* (No), *Micromys minutus* (De, Fi, Br), *Apodemus flavicollis* (De, No, Fi, Po, Br), *A. sylvaticus* (De, No, Br), *A. agrarius* (Po), *Rattus norvegicus* (Br), and *Mus musculus* (No, Fi).

Ixodes (Ceratixodes) uriae White, 1852 (synonyms: *I. putus* Pickard-Cambridge, 1876; *Ceratixodes putus* Neumann, 1902; *C. uriae* Schulze, 1938). The seabird tick

I. uriae inhabits islands and mainland coasts in the subarctic and temperate regions of the northern and southern hemispheres. The geographical distribution of *I. uriae* in Sweden and in northern Europe is given in Tables 1 and 2.

I. uriae parasitizes colony-nesting marine birds. More than 48 bird species have been recorded as hosts of *I. uriae* (Wilson 1970). In Sweden, nymphs and adult females, infected with *B. burgdorferi* s.l., were recently recorded in large numbers on *Uria aalge* and *Alca torda* at Bonden in the Baltic Sea; nymphs, males, and females were also collected from the vegetation on that island (Olsen et al. 1993). In Norway the species was recorded from the following colony-nesting seabird species: *Phalacrocorax aristotelis, Rissa tridactyla, U. aalge, Cepphus grylle,* and *Fratercula arctica* as well as from humans visiting bird colonies (Mehl 1983, Mehl & Traavik 1983).

Ixodes (Scaphixodes) caledonicus Nuttall, 1910 (synonyms: *I. caledonicus* var. *sculpturatus* Schulze, 1929; *I. berlesei* Pomerantzev, 1950)

The general distribution of *I. caledonicus* is from Ireland through central and northern Europe, Yugoslavia, Crimea, Caucasia, and Tadzikistan (Kolonin 1981). The distribution so far re-

Table 1. Geographical distribution of tick species in Sweden

Tick species	SK	BL	HA	SM	ÖL	GO	GS	ÖG	VG	BO	DS	NÄ	SÖ	UP	VS	VR	GÄ	DR	HS	ME	ÅN	HR	JÄ	VB	NB	ÅS	LY
I. trianguliceps	x	x	x	x	x				x	x	x	x	x	x	x	x		x		x		x	x	x	x		
I. uriae																					x						
I. caledonicus									x																		
I. unicavatis										x																	
I. ricinus	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	
I. persulcatus																								x			
I. arboricola	x				x	x			x				x	x													
I. canisuga	x		x	x				x					x	x													
I. hexagonus	x		x					x	x	x			x	x	x	x											
I. lividus	x							x	x									x						x	x		x
H. punctata		x			x	x			x																		
H. marginatum	x				x	x																					
R. sanguineus								x					x	x						x							
A. vespertilionis	x								x	x			x														

SK, Skåne; BL, Blekinge; HA, Halland; SM, Småland; ÖL, Öland; GO, Gotland; GS, Gotska Sandön; ÖG, Östergötland; VG, Västergötland; BO, Bohuslän; DS, Dalsland; NÄ, Närke; SÖ, Södermanland; UP, Uppland; VS, Västmanland; VR, Värmland; GÄ, Gästrikland; DR, Dalarna; HS, Hälsingland; ME, Medelpad; ÅN, Ångermanland; HR, Härjedalen; JÄ, Jämtland; VB, Västerbotten; NB, Norrbotten; ÅS, Åsele Lappmark; LY, Lycksele Lappmark.

corded in Sweden and northern Europe is given in Tables 1 and 2.

All stages of the tick usually parasitize birds that nest on or frequent rocky cliff habitats (e.g., *Falco peregrinus, Columba livia, Apus apus, Corvus corax* [Arthur 1963, Kolonin 1981, Martyn 1988]). In Sweden the species has been recorded only once, as nymphs from *F. peregrinus* (Schulze 1930). In Norway it was recorded from *Sturnus vulgaris* (Mehl 1983).

Ixodes (Scaphixodes) unicavatus Neumann, 1908 (synonym: *I. tauricus* Vshivkov & Filippova, 1957)

I. unicavatus inhabits rocky marine habitats. It has been recorded only from Sweden, the British Isles (Arthur 1963, Martyn 1988), France (Guiguen et al. 1987), and Crimea (Kolonin 1981). The geographical distribution in Sweden and northern Europe is given in Tables 1 and 2.

Table 2. Geographical distribution of tick species in northern Europe

Tick species	Sw	Ic	De	No	Fi	SPe	Es	La	Li	Po	Ge	Ne	Be	Lu	BI
I. trianguliceps	x		x	x	x	x	x	x	x	x	x	x	x		x
I. uriae	x	x		x	x						x				x
I. caledonicus	x		x	x						x	x				x
I. unicavatus	x														x
I. ricinus	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
I. persulcatus	x					x	x	x	x	x	x				
I. arboricola	x		x	x	x				x	x	x	x	x		x
I. canisuga	x		x					x	x	x	x				x
I. hexagonus	x	x	x	x						x	x	x	x	x	x
I. lividus	x		x	x	x	x		x		x	x	x	x		x
H. punctata	x		x				x			x	x	x			x
H. marginatum	x		x	x	x					x	x				x
R. sanguineus	x		x	x				x		x	x	x			x
A. vespertilionis	x		x	x						x	x	x			x
I. frontalis			x	x						x	x	x			x
I. vespertilionis										x	x	x	x		x
I. apronophorus			x			x	x	x		x	x	x			x
I. festai											x				
I. rothschildi															x
I. rugicollis										x	x				
I. simplex										x	x				
D. reticulatus						x			x	x	x		x		x
D. marginatus			x						x	x	x				
H. concinna										x	x				
H. leachi			x												
A. polonicus										x					
A. reflexus			x							x	x	x	x		x

Sw, Sweden; Ic, Iceland; De, Denmark, No, Norway; Fi, Finland; SPe, St. Petersburg region of Russia; Es, Estonia; La, Latvia; Li, Lithuania; Po, Poland; Ge, Germany; Ne, The Netherlands; Be, Belgium; Lu, Luxemburg; BI, British Isles.

Table 3. Previous and new records of tick host infestation in Sweden

Tick species[a] / Host species	Previous records				References[b]	New records[c]				
	LL	NN	FF	MM		LL	NN	FF	MM	Total
Ixodes trianguliceps										
Sorex minutus	X	X			6	2	1			3
S. araneus	X	X			5, 6, 7		1			1
Neomys fodiens	X	X			5					
Myopus schisticolor								2		2
Clethrionomys rufocanus					7					
C. glareolus	X	X	X		1, 5, 6, 7	3	4	2		8
Arvicola terrestris								1		1
Microtus agrestis	X	X			5					
Apodemus flavicollis	X	X	X		5, 6			2		2
A. sylvaticus	X	X	X		5, 6			2		2
Apodemus sp.						1				1
Mus musculus		X			5					
Ixodes uriae										
Uria aalgae		X	X		11					
Alca torda		X	X		11					
Ixodes caledonicus										
Falco peregrinus		X			1					
Ixodes unicavatus										
Phalacrocorax carbo		X	X		1	1				1
Ixodes persulcatus										
Phylloscopus trochilus							1			1
Ixodes arboricola										
Strix aluco						1				1
Phoenicurus phoenicurus						1				1
Glaucidium passerinum	X				1					
Erithacus rubecula		X			9					
Muscicapa striata			X		1					
Ficedula albicollis							1		1	2
F. hypoleuca		X			1		1			1
Parus caeruleus							1	1		1
P. major	X	X			4					
Corvus monedula							1	1		1
Sturnus vulgaris	X	X	X		4	2		1		3
Ixodes canisuga										
Canis familiaris						2	7	2		8
Vulpes vulpes							5	5		6
Felis catus						1	2			3
Equus caballus						1				1
Ixodes hexagonus										
Erinaceus europaeus								2		2
C. familiaris							1	3		3
V. vulpes								2		2
Mustela erminea		X	X		1	5	8	4		10
M. vison							4	1		4
M. putorius			X		1	5	7	14		14
Martes martes							1			1
Gulo gulo						1	1	1	1	1
Meles meles			X		1	2	6	3		6
Lutra lutra	X	X	X	X	1	3	2	1		4
F. catus			X		1	1	4	5		7
Capreolus capreolus							1			1
Ixodes lividus										
Riparia riparia	X	X	X		1, 8	1	1	9	1	9
Haemaphysalis punctata										
Homo sapiens			X	X	2			3	2	4
Lepus timidus			X	X	2		1			1
Oryctolagus cuniculus	X	X	X		5					
A. sylvaticus	X				5					
M. musculus	X	X			5					
C. familiaris						1	1	2	1	4
F. catus							1	1	1	1
Ovis aries							3	1		4
Haematopus ostralegus	X				1, 2	1	1			2
Sylvia communis							1			1
Larus ridibundus			X		1, 2					
Motacilla alba		X			3					
P. phoenicurus			X		3					

Table 3. Continued

Tick species[a] / Host species	Previous records				References[b]	New records[c]				
	LL	NN	FF	MM		LL	NN	FF	MM	Total
Hyalomma marginatum										
Anthus trivialis		X			4					
M. alba		X			1					
Acrocephalus schoenobaenus							1			1
Sylvia atricapilla						1				1
F. albicollis						1				1
Rhipicephalus sanguineus										
C. familiaris					10	3	4	2		6
Argas vespertilionis										
H. sapiens							2			2
Eptesicus nilssoni	X				1					
Pipistrellus pipistrellus						1				1
C. familiaris										

LL, larvae; NN, nymphs; FF, females; MM, males.

[a] Excluding *I. ricinus*.

[b] References: 1, Schulze 1930; 2, Schulze 1939; 3, Arthur 1952; 4, Brinck et al. 1965; 5, Brinck et al. 1967; 6, Nilsson 1974; 7, Brinck-Lindroth et al. 1975; 8, Ulmanen et al. 1977; 9, Nosek & Balát 1982; 10, Christensson 1988; 11, Olsen et al. 1993.

[c] Numbers under new records denote the number of host individuals on which the tick stage was recorded and the total number of host individuals with ticks of that particular species.

This tick is a specific parasite of *Phalacrocorax carbo* and *P. aristotelis* but has been recorded from other marine and coastal birds (e.g., the rock pipit, *Anthus spinoletta* [Arthur 1963]).

In the same collection (Museum of Natural History, Gothenburg) where nymphs and females previously were found from *P. carbo* (Schulze 1930), we found two larvae of *I. unicavatus* collected in November 1906 from *P. carbo*. There seems to be no recent record of this tick species from northern Europe.

Ixodes (Ixodes) ricinus (L., 1758) (synonyms: *Acarus ricinoides* de Geer, 1778; *I. reduvius* Latreille, 1806). The common tick, wood tick, castor bean tick, sheep tick, pasture tick

The general distribution of *I. ricinus* is through most parts of Europe eastward to the Volga River. In Asia, it is present in Turkey, northern Iran, Caucasia, and western Kopet-Dag. In Africa it is recorded from Madeira, Morocco, Algeria, and Tunisia (Kolonin 1981). The geographical distribution of *I. ricinus* in Sweden and northern Europe is given in Tables 1 and 2. Fig. 2 shows the detailed distribution of *I. ricinus* in Sweden. The detailed distributions of *I. ricinus* in Norway and Finland are given by Mehl (1983) and Öhman (1961), respectively.

I. ricinus is the most commonly observed tick species in Sweden, where it has been recorded from 29 mammal species, 56 bird species, and two lizard species (Table 4). Thus, the host range of *I. ricinus* is very wide and appears to embrace practically all terrestrial mammals living in areas where the species occurs. All stages parasitize medium- to large-sized mammals. Larvae and nymphs are also found on small mammals, birds, and reptiles. Schulze (1929), Johnsen (1946), and Brinck et al. (1984) provided Danish host records of *I. ricinus*. In Norway, Mehl (1983) recorded *I. ricinus* from 49 vertebrate species, including humans, domestic animals (five species), other mammals (15 species), birds (27 species), and one reptile species. In the British Isles *I. ricinus* was recorded from two lizard species, 49 bird species, and 33 mammal species (Martyn 1988).

Ixodes (Ixodes) persulcatus Schulze, 1930

The general distribution of *I. persulcatus* is from eastern Europe to China and Japan. The geographical distribution of *I. persulcatus* in Sweden and northern Europe is given in Tables 1 and 2.

The immature ticks are usually found on small mammals and birds. Adults are parasitic on many species of large and medium-sized mammals. The only Swedish record is one fully engorged nymph collected from a *Phylloscopus trochilus* captured 19 May 1992 on the island Stora Fjäderägg (VB) in the Bothnian Sea.

Ixodes (Pholeoixodes) arboricola Schulze & Schlottke, 1929 (synonyms: *I. dryadis* Schulze & Schlottke, 1929; *I. strigicola* Schulze & Schlottke, 1929; *I. passericola* Schulze, 1933)

The general distribution of *I. arboricola* includes northern and central Europe, Bulgaria, Byelorussia, Crimea, Transcaucasia, western Siberia, the Middle East, Afghanistan, southern Primorskij Region, China, and Egypt (Kolonin 1981). The geographical distribution in Sweden and northern Europe is given in Tables 1 and 2.

I. arboricola parasitizes any bird or bat that nests or roosts in tree cavities, bird houses, and similar habitats (Martyn 1988). In Sweden the tick is recorded from 11 species of birds (Table 3). In Denmark it is recorded from *Parus major, head of owl,* and *hole in apple tree* (Schulze 1929), *Phoenicurus ochruros, Muscicapa striata, Ficedula hypoleuca, Sitta europaea* (Haarlöv

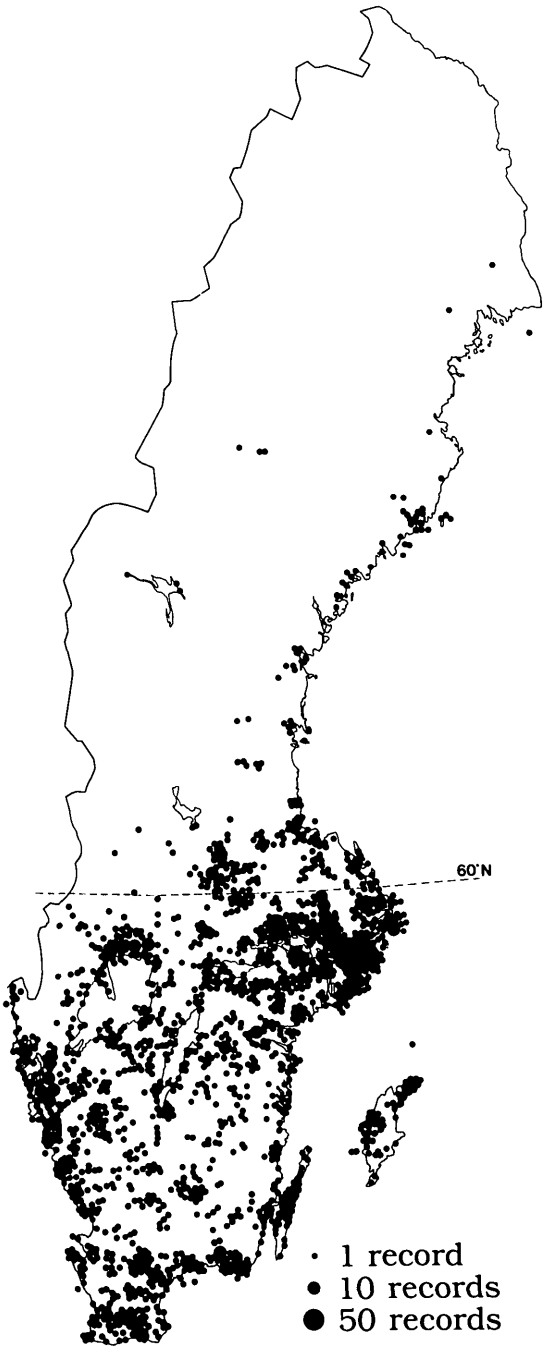

Fig. 2. Records of *I. ricinus* from Sweden. Each record indicates one or more ticks recorded from one locality or host by one collector.

1962, Johnsen 1946), and in nest of *Sturnus vulgaris* (Arthur 1955). In Norway it is recorded from *Dendrocopus leucotos, F. hypoleuca,* and *S. vulgaris* (Mehl 1983) and in Finland from *Parus major* (Saikku et al. 1971). According to Arthur (1963), Cerny & Balát examined 129 bird species in Moravia and Slovakia. They found *I. arboricola* on *Ficedula albicollis, Parus palustris, P. cristatus, P. ater, P. caeruleus, P. major, Passer domesticus,* and *P. montanus.*

Ixodes (Pholeoixodes) canisuga Johnston, 1849 (synonyms: *I. melicola* Schulze & Schlottke, 1929; *I. sciuricola* Schulze, 1932; *I. vulpicola* Schulze, 1937; *I. vulpinus* Schulze, 1937; (?) *I. crenulatus* Koch, 1844)

The area of general distribution of *I. canisuga* covers Eurasia from the Atlantic Ocean to the Pacific (Kolonin 1981). The geographical distribution of *I. canisuga* in Sweden and northern Europe is given in Tables 1 and 2.

I. canisuga parasitizes medium-sized and large mammals that regularly return to a nest or lair, particularly mustelids (Kolonin 1981). In Sweden the tick is recorded from four mammal species (Table 3). In Denmark it is recorded from a nest of *Erinaceus europaeus* (Arthur 1955), from *Meles meles* (Schulze 1929, and, as *I. melicola* [Arthur 1955, Johnsen 1946]), and from *Vulpes vulpes* (as *I. vulpicola* [Johnsen 1946]). In Germany most records are from *Canis familiaris, V. vulpes, Mustela putorius, Martes foina,* and *Felis catus* (Liebisch & Walter 1986). Most records in the British Isles are from *C. familiaris, V. vulpes, Mustela nivalis, M. vison,* and *Meles meles* but a few are from *Equus caballus, Ovis aries,* and birds (the ones from birds may be misidentified *I. arboricola*) (Arthur 1963, Martyn 1988).

Ixodes (Pholeoixodes) hexagonus Leach, 1815 (synonyms: *I. autumnalis* Leach, 1815; *I. erinaceus* Edwards, 1839). The hedgehog tick

The general distribution of *I. hexagonus* covers Europe and northwestern Africa (Kolonin 1981). The geographical distribution of *I. hexagonus* in Sweden and northern Europe is given in Tables 1 and 2.

This tick parasitizes mammals having a permanent dwelling such as carnivores, particularly mustelids and dog, and hedgehog, but can occasionally be found on other mammal species and birds (Kolonin 1981, Mehl 1983, Martyn 1988). In Sweden it is recorded from 12 mammal species (Table 3). Host records of *I. hexagonus* have also been given from Denmark (Schulze 1929, Arthur 1955), Norway (Mehl 1983), Germany (Liebisch & Walter 1986), former Czechoslovakia (Cerny 1972) and the British Isles (Martyn 1988): *Homo sapiens* (Ge, BI), *Erinaceus europaeus* (No, Ge, Ch, BI), *Lepus europaeus* (Ch), *Canis familiaris* (De, Ge, BI), *Vulpes vulpes* (No, Ge, Ch), *Mustela erminea* (BI), *M. vison* (No), *M. putorius* (De, Ch), *Martes martes* (De, No) and *M. foina* (De), *Meles meles* (No, Ch), *Lutra lutra* (No), *Felis catus* (No, Ge), and *Capreolus capreolus* (Ge).

Ixodes (Pholeoixodes) lividus Koch, 1844 (synonyms: *I. plumbeus* Leach, 1815; *I. hirundinicola* Schulze, 1944). The sand martin tick

Table 4. Previous and new records of *I. ricinus* host infestation in Sweden

Host species	Previous records				References[a]	New records[b]				
	LL	NN	FF	MM		LL	NN	FF	MM	Total
Homo sapiens		X	X	X	2	4	139	112	25	268
Erinaceus europaeus		X	X		1, 2			2		2
Sorex minutus						8	1			8
S. araneus	X				6	14	4			14
Sorex sp.						9				9
Neomys fodiens						1	1			2
Talpa europaea						1				1
Lepus europaeus						14	14	13	12	16
L. timidus						5	6	4	3	7
Lepus sp.			X		1					
Oryctolagus cuniculus	X	X	X		6	1	4	3	2	5
Sciurus vulgaris		X	X		1	8	16			18
Clethrionomys glareolus	X	X			6	69	15			69
Microtus agrestis	X	X			6	1				1
Apodemus flavicollis	X	X			6	45	5			46
A. sylvaticus	X	X			6	7	3			7
Apodemus sp.						11	1			11
Rattus norvegicus	X	X			6					
Mus musculus	X	X	X		6	1				1
Canis familiaris			X	X	1, 3	2	10	1,239	358	1,347
Vulpes vulpes						1		2	2	4
Mustela putorius	X				1					
Martes martes						1				1
Meles meles						4	4	5	2	7
Felis catus							9	353	62	392
Equus caballus							2	9		12
Cervus dama					1			2	2	2
C. elaphus		X	X	X	1					
Alces alces			X	X	1	5	6	10	14	12
Capreolus capreolus					1	25	32	38	27	44
Bos taurus			X	X	1, 2		2	42	22	42
Ovis aries						1		2		3
Somateria mollissima							3			3
Accipiter nisus		X			4		1			1
Crex crex	X	X			5					
Tetrao tetrix							2			2
Perdix perdix						1	1			1
Phasianus colchicus						1	1			1
Haematopus ostralegus						1	2			2
Larus canus						1	1			1
Hirundo rustica							1			1
Anthus trivialis	X	X			4, 5, 7	9	49			56
A. pratensis		X		X	4, 7	2				2
Motacilla flava	X	X			4, 5		3			3
Troglodytes troglodytes		X			5, 7	2	6			6
Prunella modularis	X	X			5, 7		2			2
Erithacus rubecula	X	X			1, 4, 5, 7	37	45			70
Luscinia luscinia	X	X			5	12	16			24
L. svecica		X			4	1	9			10
Phoenicurus phoenicurus	X	X			4, 5, 6	12	37			42
Oenanthe oenanthe							1			1
Turdus merula	X	X			5	6	20		1	21
T. pilaris		X			4, 5		4			4
T. philomelos	X	X			4	7	18			21
T. iliacus	X	X			4	6	23			23
Acrocephalus schoenobaenus		X			4					
A. palustris						2	5			7
A. scirpaceus						3	13			17
Hippolais icterina	X	X			5					
Sylvia nisoria		X			5					
S. curruca		X			4, 5		4			4
S. communis	X	X			4, 5	4	17	1		19
S. borin	X	X			5, 7		1			1
S. atricapilla	X				5	4	2			5
Phylloscopus trochiloides		X			5					
P. sibilatrix	X	X			5					
P. collybita							4			4
P. trochilus	X	X			4, 5	5	40			45
Muscicapa striata	X	X			4		1			1
Regulus regulus						1	4			5

Table 4. Continued

Host species	Previous records				References	New records[b]				
	LL	NN	FF	MM		LL	NN	FF	MM	Total
Ficedula parva						1				1
F. hypoleuca	X	X			1, 5		2	1		3
Parus palustris		X			5		1			1
P. montanus	X	X			1					
P. major	X	X			1, 5	1	3			4
Garrulus glandarius						2	6			6
Pica pica							1			1
Nucifraga caryocatactes							1			1
Sturnus vulgaris	X	X			5	2	2		1	3
Fringilla coelebs	X				5	1	2			3
F. montifringilla		X			5		2			2
Carduelis chloris		X			5		2			2
C. flammea						1				1
Loxia curvirostra		X			5					
Pyrrhula pyrrhula		X			5	1	2			2
Coccothraustes coccothraustes						3	3			3
Emberiza citrinella							1			1
E. schoeniclus							2			2
Lacerta vivipara						3	2			3
L. agilis						1	1			1

LL, larvae; NN, nymphs; FF, females; MM, males.

[a] References: 1, Schulze 1930; 2, Schulze 1939; 3, Brinck 1944; 4, Arthur 1952; 5, Brinck et al. 1965; 6, Brinck et al. 1967; 7, Nosek & Balát 1982.

[b] Numbers under new records denote the number of host individuals on which the tick stage was recorded and the total number of host individuals infested by *I. ricinus*.

This species is distributed from Ireland through central Europe and Asia to northeastern Mongolia and Japan (Kolonin 1981). The geographical distribution of *I. lividus* in Sweden and northern Europe is given in Tables 1 and 2.

I. lividus is found generally only on *Riparia riparia* or on other bird species using sand martin nests (e.g., *Parus major* [Ulmanen et al. 1977]), but it has been found in Japan several times in nests of the house martin, *Delichon urbica*. The males do not occur on the hosts (Arthur 1963). This tick has been recorded several times from *R. riparia* in Sweden (Table 3).

Dermacentor variabilis (Say, 1821). The American dog tick

There is no previous record from northern Europe of this New World tick, but in mid-July 1989 a flat female *D. variabilis* was found crawling on the arm of an American woman visiting a summerhouse at Kungsör (SÖ). The woman had left her home outside Boston, MA, 2 d earlier to fly directly via Brussels to Gothenburg, Sweden.

Haemaphysalis (Aboimisalis) punctata Canestrini & Fanzago, 1877 (synonym: *H. cinnabarina* var. *punctata* Nuttall & Warburton, 1915)

The general distribution of *H. punctata* is throughout the Palaearctic to Kirghezia, Uzbekistan, Tadzhikistan, and Iran. It is also recorded from Algeria, Egypt, and Japan (Pomerantzev 1950, Arthur 1963). The geographical distribution of *H. punctata* in Sweden and northern Europe is given in Tables 1 and 2.

The main hosts of adult *H. punctata* are cattle, sheep, goats, deer, horses, and other large mammals. The adult ticks are more rarely found on small mammals and birds and only infrequently attach to humans (Arthur 1963). The immatures are more commonly found on birds, small mammals, and lizards (Arthur 1963, Guiguen et al. 1987, Martyn 1988). In Sweden it is recorded from eight mammal species and five bird species (Table 3). In Denmark males and females were recorded from *O. aries* (Schulze 1929), a larva from *Philomachus pugnax* (Arthur 1955), and a female from *Syrrhaptes paradoxus* (Schulze 1929).

Hyalomma (Euhyalomma) marginatum Koch, 1844. The Mediterranean Hyalomma

All records in northern Europe appear to be, or originate from, ticks transported as larvae or nymphs by birds during their northward spring migration. *H. m. marginatum* is the European-Asiatic subspecies and is regularly found in southern Europe and northern Africa. *H. m. rufipes* Koch is regularly found in Africa but has also been recorded from Turkey, Israel, Iraq, Transcaucasia, Astrakhan, and Kazakhstan (Hoogstraal 1956). The geographical distribution of *H. marginatum* in Sweden and northern Europe is given in Tables 1 and 2.

In Sweden *H. marginatum* has been recorded from five species of birds (Table 3). One male *H. m. marginatum* was found on the Danish island Bornholm in early June 1939. This tick had presumably been transported as a nymph on a migrant bird from the Mediterranean or Africa

(Johnsen 1943). We recorded one nymph from a *Falco tinnunculus* captured in May 1991 on the Danish island Christiansö. Nymphs have been recorded in Norway during mid-May to early June from *Phoenicurus phoenicurus, Acrocephalus scirpaceus, Phylloscopus trochilus,* and *Lanius collurio* (Mehl et al. 1984). Both *H. m. marginatum* and *H. m. rufipes* have been found on migrating birds in Finland (Nuorteva & Hoogstraal 1963, Saikku et al. 1971). The adults are parasitic on large mammals and hares (Pomerantzev 1950) and are usually not found in northern Europe, probably because these ticks, like the birds that bring them, cannot survive the northern European winters (Martyn 1988).

Hyalomma (Hyalommasta) aegyptium (L., 1758). The tortoise tick

H. aegyptium does not belong to the northern European fauna but is included in this review because the species has been found in Sweden many times on imported turtles. *H. aegyptium* is a parasite of tortoises in the Mediterranean area and Near East (Pomerantzev 1950, Hoogstraal 1956) but may occasionally parasitize mammals (Pomerantzev 1950, Arthur 1963). Nymphs and males were recorded from Sweden by Schulze (1930).

Rhipicephalus (Rhipicephalus) sanguineus (Latreille, 1806) (synonym: *R. rossicus* Jakimov & Kohl-Jakimova, 1911). The kennel tick, brown dog tick

R. sanguineus is probably the most widely distributed tick species. It is presumed to have originated in Africa and has since spread to nearly every country between latitudes 50°N and 35°S (Hoogstraal 1956). The geographical distribution of *R. sanguineus* in Sweden and northern Europe is given in Tables 1 and 2.

Many of the records of *R. sanguineus* refer to ticks imported with dogs from Africa and southern Europe. The climate prevents the establishment of permanent outdoor breeding populations of *R. sanguineus* in northern Europe. However, we have observed that local populations can thrive for many months indoors in Sweden in places where dogs are being kept. The species has been recorded from dogs in Sweden on several occasions (Table 3). Several records of *R. sanguineus* infestation as a result of importation of dogs from southern latitudes and subsequent dispersal of the ticks from quarantine stations, animal hospitals, or other places have also been reported in Denmark (Winding & Haarlöv 1968, Willeberg 1970, Winding et al. 1970). Although most records of *R. sanguineus* in northern Europe are associated with dogs, this tick may also be imported with plants from southern latitudes (Centurier et al. 1979).

Argas (Carios) vespertilionis (Latreille, 1802) (synonym: *A. pipistrellae* Audoin, 1832)

The general distributional area of *A. vespertilionis* is Europe, Asia and Africa, and, provided the identifications are correct, Australia (Arthur 1963, Martyn 1988). Its geographical distribution in Sweden and northern Europe is given in Tables 1 and 2.

A. vespertilionis is host-specific to bats; almost any bat species will serve as host (Arthur 1963). In Sweden it has been recorded from two species of bats and from a dog (Table 3). It was recently recorded by one of us (T.G.T.J.) as causing severe skin reactions with fever, ulceration, erythema, and edema on the legs and arms of two persons who had been bitten by ticks in a bedroom near Stockholm (UP, Färentuna; May–June 1993). Shortly before that incident unidentified bats had been roosting in the loft above the bedroom. In Norway the species has been recorded from *Myotis mystacinus, M. daubentoni, Pipistrellus pipistrellus,* and *Eptesicus nilssoni* (Mehl 1983). This tick readily bites humans (Hoogstraal 1956).

Tick Species Not Recorded from Sweden but Present in Adjacent Territories

Following, we list tick species that have not been recorded from Sweden but, because of their occurrence in adjacent areas, may have the potential to occur in this country permanently or at least temporarily.

Ixodes (Trichotoixodes) frontalis (Panzer, 1795) (synonym: *I. pari* Leach, 1815)

The area of general distribution of *I. frontalis* is Europe and Asia to Kurgansk, Turkmenia, and northern Iran. It has also been recorded from North Africa and the Philippines (Kolonin 1981).

This tick parasitizes birds, particularly Passeriformes (Arthur 1963, Kolonin 1981, Martyn 1988). In Denmark four nymphs were found on a *Turdus merula* in the latter half of the nineteenth century (Arthur 1955) and one female on a *T. pilaris* (Schulze 1929). In Norway the species was collected from *Prunella modularis* (1 female in April 1965 [Mehl et al. 1984]) and *Phylloscopus trochilus* (1 nymph in May 1971 [Mehl 1983]).

Ixodes (Eschatocephalus) vespertilionis Koch, 1844

This tick is distributed in Europe, the former Soviet Union, northern Iran, Afghanistan, China to Japan, and Africa. It parasitizes bats (Arthur 1963, Kolonin 1981, Martyn 1988).

Ixodes (Ixodes) apronophorus Schulze, 1924 (synonym: [?] *I. arvicolae* Warburton, 1926)

The general distribution of this species is Europe and the former Soviet Union.

This tick is a parasite of small mammals (Cerny 1972, Radda et al. 1986, Martyn 1988), particularly *Arvicola terrestris, Ondathra zibetica,* and *Myocastor coypus* (Arthur 1963, Kolonin 1981). It has been recorded from Denmark (Arthur 1955).

Ixodes (Ixodes) festai Rondelli, 1926

I. festai appears to be a Mediterranean species, all stages of which parasitize birds, particularly Turdidae (Gilot 1984). *I. festai* has been confused with *I. ventalloi* Gil Collado, but was shown to be distinct from that species by Gilot & Perez (1978). *I. festai* has been recorded from birds captured on the coast of northern Germany (Walter 1979, Liebisch 1991).

Ixodes (Multidentatus) rothschildi Nuttall & Warburton, 1911

This tick parasitizes seabirds in England, Ireland, Wales, and France (Kolonin 1981, Guiguen et al. 1987, Martyn 1988).

Ixodes (Pholeoixodes) rugicollis Schulze & Schlottke, 1929

This tick is recorded from France, Germany (Kolonin 1981), and Poland (Siuda 1987). It has been found on *Vulpes vulpes* and *Martes* spp. (Kolonin 1981).

Ixodes (Pomerantzevella) simplex Neumann, 1906

This species parasitizes bats in central and eastern Europe, Asia, New Guinea, Australia, and Africa (Kolonin 1981).

Dermacentor (Dermacentor) reticulatus (F., 1794) (synonyms: *D. pictus* Olenev, 1931; *D. pictus* Schulze, 1933. The name *D. pictus* is used by Russian authors for the designation of the true *D. reticulatus* [Estrada-Peña 1990]). The marsh tick, *tique du chien* (=dog tick) in central France

Its general distribution is from the Iberian Peninsula and France through eastern Europe and western Siberia to China except the northern regions (Estrada-Peña 1990).

The principal hosts of the adult ticks are large mammals. The immatures generally parasitize smaller mammals and occasionally birds (Arthur 1963, Martyn 1988, Estrada-Peña 1990). This is a common parasite of dogs in France (Senevet 1937, Winding et al. 1970).

Dermacentor (Dermacentor) marginatus (Sulzer, 1776)

The general distribution of this tick is from Spain, France, and Switzerland through eastern and southern Europe to Caucasia, Kazakhstan, Turkmenia, and Tadzhikistan to Afghanistan (Estrada-Peña 1990).

The subadult ticks are parasitic on small mammals and occasionally on birds, whereas the adults parasitize medium-sized and large mammals including humans (Babos 1964, Radda et al. 1986, Estrada-Peña 1990).

Haemaphysalis (Haemaphysalis) concinna Koch, 1844

This species is distributed from France, western and eastern Germany, and Poland through the former Soviet Union and China to Japan (Estrada-Peña 1989).

The subadult ticks are parasitic on birds and mammals including humans. Adult ticks are generally found on large and medium-sized mammals (Babos 1964).

Haemaphysalis (Rhipistoma) leachi (Audouin, 1827) (synonym: *Rhipistoma ellipticum* Koch, 1844)

This species is distributed in Africa and Asia (Estrada-Peña 1989). It is also recorded from Australia (Senevet 1937).

H. leachi has been imported several times to Denmark on dogs (Willeberg & Kjaersgaard 1973).

Argas (Argas) polonicus Siuda, Hoogstraal, Clifford & Wassef, 1979

This tick was collected from St. Mary's Church in Krakow, Poland, where it feeds on *Columba livia* (Siuda et al. 1979).

Argas (Argas) reflexus (F., 1794). The pigeon tick

The general distribution of this species is the Near East and the Middle East from where it has spread to Europe, Russia, India, and Africa (Arthur 1963). In Denmark this tick has been found several times in pigeonries (Christiansen 1934, Arthur 1955, Hallas 1978). The main host of *A. reflexus* is the domestic pigeon (*Columba livia*), although humans, chickens, and horses are frequently attacked (Arthur 1963).

Otobius (Otobius) megnini (Dugès, 1883). The spinose ear tick

This tick is a parasite on livestock, dogs, and large wildlife, but rarely on humans. It is recorded from Denmark (Hallas 1978). The distributional area of *O. megnini* is southwestern and western United States, Mexico, Central and South America, Africa, and India (USDA 1976).

Discussion

Based on the number of blood meals from individual hosts, the tick life cycle can be classified as mono-, di-, or triphasic among ixodids and polyphasic among argasids (Aeschlimann 1984). Parasitic specificity can be defined as the number of host groups that are parasitized by the different life stages of a tick species (Aeschli-

mann 1984). A host group may be a single species, a higher taxonomic unit (e.g., rodents), or hosts found in a similar ecological niche (e.g., birds nesting in tree holes). Monotropic ticks feed on the same group of hosts during all stages. Ditropic ticks parasitize one group of hosts in the subadult stages and another group as adults. In telotropic ticks the subadults show no particular host preference, but the adults prefer large mammals. The behavior of the questing tick may be divided into two patterns: endophilic ticks always quest under cover such as in small mammals' burrows, birds' nests, and human habitations; endo/exophilic ticks also may quest in the open such as in vegetation. No ticks are known to be strictly exophilic (Aeschlimann 1984).

The tick species occurring naturally in Sweden may be classified into three groups: (1) monotropic endophilic bird-feeding (ornithophagous) species, (2) monotropic endophilic mammal-feeding (mammalophagous) species, and (3) telotropic endo/exophilic species that frequently feed on both birds and mammals.

There are five species of monotropic endophilic bird-feeding ticks known from Sweden (*I. uriae, I. caledonicus, I. unicavatus, I. arboricola, I. lividus*), three of which have been found here only a few times (*I. uriae, I. caledonicus, I. unicavatus*). The scarcity of records of these ticks may be because these ticks parasitize birds inhabiting places such as isolated rocky marine habitats and rocky cliffs, which are rare in those parts of Sweden where the climate is favorable for tick survival. The two other bird-feeding ticks (*I. arboricola* and *I. lividus*) are found more frequently in Sweden. *I. arboricola* parasitizes several bird species, but *I. lividus* feeds almost exclusively on sand martins or birds that use sand martin nests. The host choices of these tick species affect their geographical distribution. *I. arboricola* has been recorded only from southern Sweden, but *I. lividus* has been recorded from southern, central, and northern Sweden. *I. lividus* is probably able to exist in northern Sweden because it can survive the winter in sand martin nests, which are well-sheltered holes in sandy slopes. The scattered geographic distribution of bird-feeding ticks (e.g., *I. lividus*) may partly reflect inadequate sampling but may also reflect the ability of birds to transport ticks rapidly over long distances. Our data show that both the subadult and adult stages of *I. uriae, I. arboricola,* and *I. lividus* can be found on the avian host or in its nest.

Four species of monotropic endophilic mammal-feeding ticks are known from Sweden (*I. trianguliceps, I. canisuga, I. hexagonus, A. vespertilionis*). *I. trianguliceps* primarily parasitizes rodents and insectivores. With the exception of *I. uriae* (Mehl 1983), *I. trianguliceps* is the tick species with the northernmost distribution on the Scandinavian peninsula. The ability of this species to exist in the cold climate of northern Scandinavia is presumably that it, like *I. lividus,* parasitizes hosts having well-sheltered nests. Our data show that larvae, nymphs, and adult females of *I. trianguliceps* can be found on small mammal hosts. Absence of males on these hosts conforms with the data of Arthur (1963) and probably reflects that males of *I. trianguliceps* do not ingest blood.

I. canisuga and *I. hexagonus* have similar life habits and primarily parasitize medium-sized carnivorous mammals. Our data also suggest that all active stages of the ticks may be found on the same host. Both species are frequent in southernmost Sweden.

The bat parasite *A. vespertilionis* has been recorded on a few occasions in southern Sweden. It is probable that this tick is more abundant and more widely distributed than is shown by our records. Our data show that all active stages may be found on or in close association with bats.

Two species of telotropic endo/exophilic tick species that frequently feed on both birds and mammals belong to the Swedish fauna (*I. ricinus, H. punctata*). *I. ricinus* is the most common tick species in practically all parts of Sweden (Fig. 2). The absence of *I. ricinus* from the interior parts of northern Sweden is presumably due to the relatively cold climate. The abundance and wide distribution of this tick may be a result of it parasitizing vertebrates that are generally abundant, such as rodents and insectivores, as well as vertebrates that have great capacity for dispersal, such as birds and medium-sized and large mammals. Our data on *I. ricinus* suggest that all feeding stages may be found on large and medium-sized mammals such as *E. europaeus,* Leporidae, Canidae, Mustelidae, Felidae, Cervidae, and Bovidae. The predominance of adult female ticks and few records of larval ticks on these hosts presumably reflects the fact that the larger (adult) ticks are more easily noted by the people, mainly dog- and cat-owners, who sent most *I. ricinus* ticks from large mammals to us. All active stages of *I. ricinus,* with a predominance of nymphs followed by adult female ticks, were found on humans. Although some of the male ticks contained blood, none was attached to the skin when collected. This suggests that males of *I. ricinus* take only small blood meals ingested during brief feeding periods. Most small insectivores and rodents parasitized by *I. ricinus* harbored only larval ticks. Only 25% also harbored nymphal ticks. No adult *I. ricinus* were found among 184 small insectivores and rodents harboring subadults of this tick species. Birds and lizards were also generally parasitized only by subadults. However, on four bird species (*T. merula, S. communis, F. hypoleuca, S. vulgaris*) adult male or female *I. ricinus* were found.

H. punctata is probably the only tick species in Sweden that may be locally more abundant

than *I. ricinus*. In Sweden *H. punctata* seems to be restricted to the islands of Öland and Gotland and adjacent small islands, although occasional records from two other provinces exist. Because babesiosis of sheep, caused by *B. motasi*, is present in the Stockholm area, it is likely that the presumed vector, *H. punctata*, also occurs there (D. Christensson, National Veterinary Institute, Uppsala, Sweden; personal communication). Yet, despite the fact that the subadults frequently feed on birds, *H. punctata* appears to have been unable to establish dense populations on the Swedish mainland. This may, at least partly, be a result of competition for the same hosts from the already abundant *I. ricinus*, which uses the same hosts as *H. punctata*. Our data suggest that all stages of *H. punctata* parasitize large and medium-sized mammals. In contrast, only larvae and nymphs are found on small mammals and birds. This pattern appears similar to that of *I. ricinus*.

Several ticks in the present category of telotropic endo/exophilic species have been recorded only once or do not occur at all in Sweden although they are present in adjacent territories. They include *I. persulcatus*, *I. festai*, *D. reticulatus*, and *D. marginatus*.

Subadults of *H. marginatum* (which is a diphasic, telotropic, and endo/exophilic tick) have been found on a few occasions in Sweden on migratory birds during their spring migrations from Africa and the Mediterranean. We recorded only nymphs of *H. marginatum* on spring-migrating birds. This tick is probably unable to survive the northern European winters.

Because the subadults of ticks in this category can parasitize birds, occasional transportation by birds of these ticks is not unlikely. Failure to establish populations may be caused by unfavorable climate, competition from *I. ricinus*, or simply that the specimens introduced to a certain locality at a certain time are too few and scattered.

The efficiency of transmission of pathogens from tick vectors to humans is strongly dependent on the host specificity of the tick. If none of the tick life stages feeds on humans, the tick is unable to transmit pathogens to humans. Among ticks belonging to the northern European fauna and found in Sweden, only *I. uriae*, *I. ricinus*, *I. hexagonus*, and *H. punctata* are known to feed relatively regularly on humans if given the opportunity. All of these ticks are known or potential vectors of human disease (Nuttall et al. 1986, Liebisch et al. 1989, Marquez & Constan 1990, Gern et al. 1991, Olsen et al. 1993).

I. uriae is a vector of many parasites of birds. Viruses isolated from *I. uriae* in Norway belong to the Kyuleniy virus, the Uukuniemi and Kemerovo groups, and untyped orbivirus-like and coronavirus-like viruses (Mehl & Traavik 1983). From *I. uriae* collected in the British Isles, Faeroe Islands, and Iceland, Nuttall et al. (1986) isolated viruses of the Hughes serogroup, which has been associated with human disease. *I. uriae* may be transported by seabirds over great distances to remote islands. Thus, exotic pathogens may be introduced into islands not previously infested by *I. uriae*. We have recently detected *B. burgdorferi* s.l. in *I. uriae* and in birds parasitized by this tick in Sweden (Olsen et al. 1993). This tick attacks humans and may therefore potentially transmit *B. burgdorferi* and other pathogens or parasites of birds to humans visiting seabird colonies. The distribution of *I. uriae* in Sweden appears to be limited to one isolated island, Bonden, inhabited by marine birds, particularly auks (Alcidae), in the Baltic Sea.

I. ricinus is the main tick vector of diseases of humans and domestic animals in Sweden and, so far, the only known vector of Lyme borreliosis, tick-borne encephalitis (TBE), and *Babesia divergens* in Sweden. It is also the main vector of *Ehrlichia phagocytophila* and Uukuniemi virus, and a known vector of *Francisella tularensis* in Fennoscandia. The efficiency of *I. ricinus* as a vector of human disease depends on six factors: (1) *I. ricinus* is triphasic; (2) all life stages may feed on humans; (3) the subadults have a very wide host range, which increases their possibility of becoming infected with various pathogens; (4) the subadults often feed on hosts that are reservoirs for actual pathogens (e.g., those causing Lyme disease and TBE [Tälleklint & Jaenson 1993]); (5) *I. ricinus* is the most abundant tick species in Sweden; and (6) the species is widespread in the most densely populated regions of Sweden.

I. hexagonus may be a vector of Lyme disease in Germany and Switzerland (Liebisch et al. 1989, Gern et al. 1991), but this aspect has not yet been studied in Sweden. This tick primarily parasitizes mammals with a permanent dwelling and thus only rarely feeds on humans.

H. punctata is the presumed vector of ovine babesiosis in southeastern Sweden (Christensson 1989). It is considered to transmit tick typhus in Russia (Pomerantzev 1950). *B. burgdorferi* has been isolated from this tick in Spain (Marquez & Constan 1990). Because this tick is triphasic and the subadults feed on reservoirs for the Lyme disease spirochaete, *H. punctata* may be a medically important vector in areas where it is common.

R. sanguineus, which is regularly introduced into Sweden by the importation of dogs from southern latitudes, infrequently bites humans. This tick is a vector of several pathogens including *Rickettsia rickettsii* (Wolbach), *R. conorii* Brumpt, *Coxiella burnetii* (Derrick), *Ehrlichia canis* (Donatien & Lestoguard), and *Babesia canis* (Piana & Galli-Valerio).

We recently recorded attacks of the bat parasite *A. vespertilionis* on two people in their bedroom during May–June 1993 near Stockholm.

The ticks were coming from the loft above the bedroom where bats had been breeding. The tick bites on the legs and arms caused severe reactions with erythema, edema, ulceration, and fever. The persons were seen by a physician, who diagnosed the symptoms as erysipelas and dismissed the patients' claim that the ulcers were caused by tick bites. After 10 d treatment with penicillin the condition had improved, and the ulcers started to heal.

I. persulcatus, D. reticulatus, and *A. reflexus* do not seem to have established permanent populations in Sweden although these ticks are present in adjacent areas. They have been incriminated as vectors of human and animal diseases. *I. persulcatus* is an important vector of Lyme disease and tick-borne encephalitis in eastern Europe and Asia. Because subadult *I. persulcatus* frequently parasitizes birds, it is likely that larvae and nymphs occasionally dislodge in southern and eastern Sweden from spring-migrating birds coming from eastern Europe and Asia. However, *I. persulcatus* does not seem to have established a population in Sweden, most likely because the introduced ticks are too few and too scattered. *D. reticulatus* is present on the North Sea coast of Germany. This species is a vector of bovine, canine, and equine babesioses (Arthur 1963). *A. reflexus* is primarily a parasite of domestic pigeons, to which it transmits *Borrelia anserina* Bergey, Harrison, Breed, Hammer & Huntoon. Because this tick rarely feeds on humans, it may be of only peripheral medical importance.

The fact that potential vectors of serious human diseases can be rapidly transported from remote countries to Sweden was established during this study. In 1989 a woman living outside Boston, MA, found an adult female of *D. variablis* on herself while on vacation in Sweden. It is most likely that the tick had been transported from Massachusetts to Sweden in the woman's luggage. This North American dog tick is a main vector in eastern North America of *Rickettsia rickettsii,* the etiological agent of Rocky Mountain spotted fever. This tick may also cause tick paralysis in man, transmit *Anaplasma marginale* Theiler, the etiological agent of bovine anaplasmosis, and is considered to be responsible for the maintenance of tularemia in American rodent populations (USDA 1976). In view of the large number of people, animals, and materials constantly transported across the world, the potential for accidental introduction to countries of exotic tick-borne pathogens of man and animals is evident.

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