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Migrating birds at Ottenby Sweden as carriers of ticks and possible transmitters of tick-borne encephalitis virus[1, 2]

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Abstract

Investigations of birds trapped at the Ottenby Bird Station on the island of Öland in the Baltic Sea demonstrated that ticks are carried by numerous bird species, particularly Passeriformes. The resident bird population as well as birds undertaking migration were found to be infested. So far among birds undertaking long-range migration infestation was made probable only for individuals coming in from the south in spring. The tick species most commonly encountered was *Ixodes ricinus*, while *I. arboricola* and *Hyalomma marginatum* were occasionally represented, the last mentioned in but a single case. Infestation rates during autumn migration were: in early August, 0 % (62 birds of 7 species examined), in September 8.8 % (136 birds of 14 species), and in October 5.4 % (93 birds of 11 species). In most cases only one or a few ticks were taken off each bird. The maximum numbers were as follows: 49 *I. ricinus* on a Blackbird, 54 *I. arboricola* and 13 *I. ricinus* on a Starling and 65 *I. ricinus* on a Blackbird. Only larval and nymphal ticks were encountered, except 1 ♀ of *I. arboricola*.

Examination of blood samples to demonstrate presence of tick-borne encephalitis virus was negative and only one of 291 serum samples neutralized this type of virus; it was collected from a Garden Warbler (*Sylvia borin*). The individuals of this bird species passing Ottenby on their way to tropical and southern Africa originate from the Baltic islands or the coastal areas around the northern and central Baltic Sea.

Резюме

Мигрирующие птицы Оттенбю (Швеция) как переносчики клещей и возможные передатчики вируса клещевого энцефалита

Исследования птиц, пойманных на орнитологической станции Оттенбю (остров Эланд в Балтийском море) показали, что некоторые представители группы воробьиных являются переносчиками клещей. Постоянно живущие на острове Эланд популяции птиц как правило заражены клещами. Из перелетных видов зараженными оказались лишь птицы, прилетающие весной с юга.

Среди клещей наиболее часто встречается *Ixodes ricinus*, в то время как представители *I. arboricola* и *Hyalomma marginatum* единичны (последний вид зарегистрирован один раз). Степень зараженности птиц во время осенних миграций: в начале августа – 0 % (62 птицы 7 видов), в сентябре – 8,8 % (136 птиц 14 видов), в октябре – 5,4 % (93 птицы 11 видов). На большинстве обследованных птиц найдено 1 или несколько клещей. Максимальные количества клещей: 49 экземпляров *I. ricinus* на черном дрозде, 54 экземпляра *I. arboricola* и 13 экземпляров *I. ricinus* на скворце и 65 экземпляров *I. ricinus* на черном дрозде. Обнаружена лишь одна взрослая самка *I. arboricola* остальные клещи – неполовозрелые.

Исследования проб крови птиц на присутствие вируса энцефалита дали преимущественно отрицательный результат, но одна из 291 проб дала нейтральную реакцию на присутствие вируса. Это была проба крови садовой славки (*Sylvia borin*).

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1. Introduction

Pavlovsky (1940), knowing that birds carry ticks, realized that they might serve as transmitters of tick-borne diseases to man and domestic animals and this was later confirmed as regards spread of infections within natural foci (cf. Korenberg 1962).

It has also been suggested that the long-range movements of migrating birds might result in transportation of infected ticks to previously uninfected areas and so be responsible for establishing tick-borne viruses in new areas. Hoogstraal et al. (1961a, b, 1963) have demonstrated that there is a considerable intercontinental transport of ticks by migrating birds.

Finally, a local tick population may be infected by feeding on viremic birds. According to Blaškovič (1963), however, this possibility has probably been overestimated.

2. Previous records of ticks from birds in Sweden

There are few exact records of ticks from birds in Sweden. Schulze (1930) recorded *Ixodes arboricola* Schulze and Schlottke, 1929, and *Hyalomma* sp. Arthur (1952) recorded *Ixodes ricinus* (Linnaeus 1758) and *Haemaphysalis punctata* Canestrini and Fanzago, 1877.

While *I. arboricola* is essentially a bird tick, this is not true of the other three species. *I. ricinus* accepts almost any terrestrial vertebrate inhabiting or temporarily occurring in tick-infested areas. *Haemaphysalis punctata* shows a preference for large mammals.

Hyalomma sp. recorded by Schulze (1930: 17) from a White Wagtail (*Motacilla alba*) was probably a specimen of *H. marginatum* Koch (*savignyi* Gervais; cf. Hoogstraal 1956, Feldman-Muhsam 1954). This species which was hardly recognizable until Delpy's (1949) revision of the genus occurs in the present material and was also recorded by Nuorteva & Hoogstraal (1963) from northbound migrating birds, in southernmost Finland. The specimen examined by Schulze (a mutilated nymph) is not in the Natural History Museum, Göteborg, where the rest of Schulze's material from 1930 is deposited. The race so far collected in central and northern Europe is *H. marginatum* f. typ. which is widespread in southern Europe, south-western USSR and also occurs in north-western Africa. The African subsp. *rufipes* Koch has been collected in Egypt on northbound migrating birds, and Hoogstraal et al. (1961b) suggest that it may be carried some distance into Europe and Asia.

3. Habits of bird ticks collected in Sweden

So far the following species of ticks have been collected on birds in Sweden: *Ixodes arboricola* Schulze & Schlottke, *I. ricinus* L., *Haemaphysalis punctata* Can. and Fanz., and *Hyalomma marginatum* Koch. Some data on these species are given below, having particular regard to *I. ricinus*, an important vector of tick-borne diseases.

I. arboricola appears to occur on birds throughout the year (Arthur 1963). The birds most likely to be parasitized by the species are those which nest in cavities of trees. The species is not known to circulate virus diseases to man or domestic animals.

I. ricinus is a West Palearctic species, widespread in southern and central Sweden. The larvae, nymphs and adults overwinter in suitable microhabitats in the ground, until, in the following spring, they ascend to the tips of the vegetation and acquire a host. After having fed, the females drop to the ground to oviposit. The two immature stages of the life cycle, the larva and the nymph, have to feed before moulting as must the female before oviposition. Larvae feed for 3–5 days, nymphs for 5–7 days and adult females for 7–13 days (Arthur 1963). The species transmits microorganisms responsible for diseases in man and domestic animals. In Europe, it is the main

vector of the tick-borne encephalitis (TBE) virus which circulates in amniote vertebrates.

H. punctata is widespread in southern Sweden and is comparatively abundant in certain coastal areas and on the Baltic islands where sheep, the preferred host in Sweden, are commonly kept. In Scandinavia it is occasionally collected from birds and small mammals (cf. Schulze 1939) and is met with as an accidental parasite of cattle and man. The species has not been shown to be a vector of TBE virus.

H. marginatum f. typ. occurs in the Mediterranean countries, south-western USSR and the Caucasus. There are many records of isolated specimens collected or populations established outside its normal range (cf. Hoogstraal 1956). The species prefers arid conditions; in Yugoslavia it is common in the pastures along the Gulf of Trieste, mainly barren areas where only shrubs and small trees grow between rocks and stones (Vesenjak-Hirjan et al. 1965). The adults parasitize mammals, chiefly domestic animals, while the immature stages usually attack small mammals and birds and are carried by migrating birds to areas far outside its natural distribution range (Hoogstraal et al. 1963, Babos 1964). The species is the primary vector of the virus causing Crimean haemorrhagic fever and may also transmit several rickettsiae, bacteria and protozoa (Hoogstraal et al. 1963: 257).

4. Examination of migrating birds at Ottenby Bird Station

Only one quantitative investigation of ticks on birds has been carried out in Sweden (Arthur 1952) and this was not connected with an examination of the birds as carriers of tick-borne virus. In the south-eastern parts of Sweden there is a great autumn influx of migrating birds from heavily infested areas in eastern and north-eastern Europe where TBE virus is enzootic. So it was considered worth while to investigate the possibility that ticks and/or TBE virus are transported across the Baltic Sea by migrating birds. Trapping and examination of birds was carried out at the Ottenby Bird Station, on the island of Öland in the Baltic Sea. In this part of Sweden TBE virus is known to be enzootic (von Zeipel et al. 1959, Svedmyr et al. 1965 a and b).

The field work was carried out by Mr. H. Myhrberg and Mr. J. O. Strömberg.

5. Field methods

At Ottenby, from July to October 1962, 292 birds were collected either in a Heligoland trap (Hollom 1950) or, as for the waders, in a creel-like trap of local design. According to information from Mr. Myhrberg each bird was treated as follows. Under ether anesthesia, the belly was opened and the posterior ribs cut through so that a syringe needle could be placed in the heart and the blood collected under aseptic conditions. During this procedure the bird died. After bleeding, the bird was placed on a sheet of white paper in a box containing chloroform. After about five minutes the specimen was removed and examined thoroughly for ectoparasites by hand.

A considerable number (133) of the birds was infested, mainly by Acari and Mallophaga. The material of ectoparasites was sorted by Mr. C. B. Nordenberg. The ticks dealt with in this paper were identified by Miss B. Jende and Mr. C. B. Nordenberg.

6. Virological techniques

Blood samples collected under aseptic conditions were sent by mail to the virus laboratory. Following centrifugation serum and clot were stored separately at −30°C until tested.

A 50% extract of the clot, prepared by grinding in a mortar, was tested for presence of virus by i.c. inoculation of 0.02 ml into each of 5 white mice three weeks of age. The animals were observed for a period of three weeks.

Sera were tested in tissue culture for neutralizing antibodies to the Hypr strain of Western TBE virus according to methods described elsewhere (von Zeipel et al. 1959, Svedmyr et al. 1965 b). Whenever possible sera were tested undiluted (172 specimens) but due to the minimal amounts available many of them had to be diluted (1/10: 1 specimen, 1/5: 43, 1/3: 27, 1/2: 42, 1/1.5:6).

7. Field results

The field work was carried out in three periods, viz. 31/7–6/8, 5/9–15/9 and 22/10–31/10, 1962. In the first period 62 specimens of 7 species of birds were examined (Table 1); no ticks were secured. In September 137 specimens of 14 species were examined (Table 2) and 7 larval and 11 nymphal ticks were collected from 12 birds, i.e. an infestation rate of 8.8%. In October when 93 specimens of 11 species of birds were examined (Table 3), 5 specimens of birds were infested by 1 larval and 4 nymphal ticks, i.e. an infestation rate of 5.4%. All the ticks were young *Ixodes ricinus*.

8. Origin of examined birds

Most of the ticks were collected from the Robin (*Erithacus rubecula*). This is a migrant, whose Scandinavian, Finnish and northwest Russian populations undertake autumn migration in a southwest or south-southwesterly direction, though there are a few records of migration to the southeast according to information from Dr. G. Rudebeck. The above-mentioned populations spend the winter in western and southwestern Europe and in north-western Africa, i.e. in the south-western Palearctic region. Non-Swedish birds trapped and ringed during migration past Ottenby have been recovered at Leningrad (USSR), Björneborg (Finland) and Ösel island (Estonia), according to information from Mr. Myhrberg. On the other hand some specimens trapped at Ottenby may form part of the local population or originate from the Scandinavian mainland. As regards the other species of birds from which ticks were secured, e.g. the Redwing (*Turdus iliacus*), the Bullfinch (*Pyrrhula pyrrhula*), the Pied Flycatcher (*Ficedula hypoleuca*) and the Song Thrush (*Turdus philomelos*), the infested specimens were probably Fennoscandian or from the western part of the USSR. The Pied Flycatcher is a long-range migrant whose Fennoscandian populations pass the winter in tropical West Africa. The Redwing and the Song Thrush migrate towards west and south-south-west, staying in western Europe or the Mediterranean countries. The Bullfinch rarely migrates and then proceeds southwards to Central Europe.

Table 1. Birds trapped at Ottenby Bird Station on July 31–August 6, 1962, and examined for ticks.

Bird species	Age	Number collected	Number infested by ticks
Oystercatcher *Haematopus ostralegus* L.	ad.	1	0
Ringed Plover *Charadrius hiaticula* L.	juv.	10	0
	ad.	4	0
Wood Sandpiper *Tringa glareola* L.	juv.	15	0
	ad.	1	0
Common Sandpiper *Tringa hypoleucos* L.	juv.	12	0
	ad.	1	0
Dunlin *Calidris alpina* L.	ad.	14	0
Ruff *Philomachus pugnax* L.	juv.	3	0
Meadow Pipit *Anthus pratensis* L.	juv.	1	0
Total		62	0
Infestation rate 0			

Table 2. Birds trapped at Ottenby Bird Station on September 5–15, 1962, and examined for ticks.

Bird species	Age	Number collected	Number infested by ticks	Ticks collected (*Ixodes ricinus* L.) larvae	nymphs	adults
Teal *Anas crecca* L.	juv.	1	0			
Sparrow Hawk *Accipiter nisus* L.	juv.	2	0			
Ringed Plover *Charadrius hiaticula* L.	ad.	3	0			
Bar-tailed Godwit *Limosa lapponica* L.	juv.	1	0			
Dunlin *Calidris alpina* L.	juv.	15	0			
	ad.	6	0			
Ruff *Philomachus pugnax* L.	juv.	1	0			
Great Spotted Woodpecker *Dendrocopos major* L.	juv.	1	0			
Song Thrush *Turdus philomelos* Brehm.	unknown	3	1		4	
Robin *Erithacus rubecula* L.	unknown	34	9	5	7	
Garden Warbler *Sylvia borin* Bodd.	unknown	11	0			
Lesser Whitethroat *Sylvia curruca* L.	unknown	9	0			
Spotted Flycatcher *Muscicapa striata* Pall.	juv.	34	0			
Pied Flycatcher *Ficedula hypoleuca* L.	unknown	14	2	2		
Crossbill *Loxia curvirostra* L.	ad.	1	0			
Total		136	12	7	11	
Infestation rate 8.8%						

9. Virological investigations of blood samples

No mouse-pathogenic virus was demonstrated in any of the 246 blood samples tested.

Only one out of 291 sera, collected early in September from a Garden Warbler (*Sylvia borin*) neutralized TBE virus. The technique used for collection of blood excluded contamination with gastric juice or tissue components which may inactivate the virus in neutralization tests (van Tongeren et al. 1960, Blaškovič 1963). The neutralization found was therefore most probably due to specific antibodies.

No ticks were collected from this bird. It seems probable that it originated from the Baltic islands or from the Swedish east coast (cf. Brickenstein-Stockhammer & Drost 1956, Rendahl 1960). On the other hand, present knowledge on the migration of the central and north Finnish Garden Warblers is insufficient, and it may be that part of the birds passing Ottenby start from Finnish ter-

ritory. Since TBE virus is enzootic in south-eastern Sweden (von Zeipel et al. 1959) and in southern Finland, including the Åland archipelago (Oker-Blom 1956, Kääriänen et al. 1961), the bird has most probably acquired its infection with TBE virus in the Central Baltic region.

The incidence of antibodies among the birds migrating past Ottenby appears to be low even when compared to the rather low one demonstrated in small mammals in south-eastern Sweden, including Gotland (cf. Svedmyr et al. 1965 a). This might be due to rare contacts with infected ticks, since many of the birds examined probably originated from areas with no or little TBE on the Swedish mainland or Finland, but it might also be due to lack of sensitivity to this virus infection (cf. Blaškovič 1963).

10. Tick infestation in other Ottenby materials

Judging from the material brought together in 1962 by Mr. Myhrberg and Mr. Strömberg ticks are fairly rare on birds trapped at Ottenby Bird Station. As a complement to their results we should like to deal briefly with the material of two other collectors of ticks from

Table 3. Birds trapped at Ottenby Bird Station on October 22–31, 1962, and examined for ticks.

Bird species	Age	Number collected	Number infested by ticks	Ticks collected (*Ixodes ricinus* L.) larvae	nymphs	adults
Blue Tit	juv.	7				
Parus caeruleus L.	ad.	7				
	unknown	1				
Great Tit	juv.	2				
Parus major L.	ad.	1				
Redwing	juv.	5	1		1	
Turdus iliacus L.	ad.	2	1	1		
	unknown	1				
Robin	unknown	17	2		2	
Erithacus rubecula L.						
Starling	juv.	6				
Sturnus vulgaris L.						
Greenfinch	juv.	3				
Chloris chloris L.	ad.	4				
Siskin	juv.	2				
Carduelis spinus L.	unknown	4				
Redpoll	ad.	1				
Carduelis flammea L.						
Bullfinch	juv.	4				
Pyrrhula pyrrhula L.	ad.	11	1		1	
	unknown	12				
Chaffinch	ad.	1				
Fringilla coelebs L.	unknown	1				
Yellowhammer	unknown	1				
Emberiza citrinella L.						
Total		93	5	1	4	
Infestation rate 5.4%						

Table 4. Birds trapped at Ottenby Bird Station in April–September 1963 and examined for ticks with positive results.

	Number of positive birds	Species and number of specimens of ticks (la = larvae, ny = nymphs)
April		
Song Thrush (*Turdus philomelos* Brehm)	3	*Ixodes ricinus 4 ny*
Redstart (*Phoenicurus phoenicurus* L.)	2	*Ixodes ricinus* 2 ny
Robin (*Erithacus rubecula* L.)	10	*Ixodes ricinus* 5 la, 9 ny
Willow Warbler (*Phylloscopus trochilus* L.)	1	*Ixodes ricinus* 2 ny
Hedge Sparrow (*Prunella modularis* L.)	1	*Ixodes ricinus* 1 ny
Tree Pipit (*Anthus trivialis* L.)	1	*Hyalomma marginatum* 1 ny
May		
Corncrake (*Crex crex* L.)	1	*Ixodes ricinus* 1 la, 1 ny
Great Tit (*Parus major* L.)	1	*Ixodes ricinus* 1 la
		Ixodes arboricola 1 la, 1 ny
Wren (*Troglodytes troglodytes* L.)	1	*Ixodes ricinus* 1 ny
Fieldfare (*Turdus pilaris* L.)	1	*Ixodes ricinus* 1 ny
Song Thrush (*Turdus philomelos* Brehm)	2	*Ixodes ricinus* 2 la, 6 ny
Blackbird (*Turdus merula* L.)	2	*Ixodes ricinus* 3 ny
Redstart (*Phoenicurus phoenicurus* L.)	17	*Ixodes ricinus* 9 la, 31 ny
Nightingale (*Luscinia luscinia* L.)	1	*Ixodes ricinus* 1 la
Robin (*Erithacus rubecula* L.)	7	*Ixodes ricinus* 5 la, 10 ny
Garden Warbler (*Sylvia borin* Bodd.)	1	*Ixodes ricinus* 2 ny
Whitethroat (*Sylvia communis* Lath.)	3	*Ixodes ricinus* 4 la, 3 ny
Lesser Whitethroat (*Sylvia curruca* L.)	2	*Ixodes ricinus* 2 ny
Willow Warbler (*Phylloscopus trochilus* L.)	3	*Ixodes ricinus* 3 ny
Hedge Sparrow (*Prunella modularis* L.)	2	*Ixodes ricinus* 5 ny
Yellow Wagtail (*Motacilla flava* L.)	1	*Ixodes ricinus* 1 la
Starling (*Sturnus vulgaris* L.)	1	*Ixodes arboricola* 54 ny
		Ixodes ricinus 1 ny
Greenfinch (*Chloris chloris* L.)	1	*Ixodes ricinus* 1 ny
Brambling (*Fringilla montifringilla* L.)	1	*Ixodes ricinus* 1 ny
Chaffinch (*Fringilla coelebs* L.)	1	*Ixodes ricinus* 3 la
June		
Great Tit (*Parus major* L.)	1	*Ixodes ricinus* 1 ny
Blackcap (*Sylvia atricapilla* L.)	1	*Ixodes ricinus* 1 la
Whitethroat (*Sylvia communis* Lath.)	1	*Ixodes ricinus* 1 ny
Willow Warbler (*Phylloscopus trochilus* L.)	1 juv.	*Ixodes ricinus* 1 la
Icterine Warbler (*Hippolais icterina* Vieill.)	1	*Ixodes ricinus* 1 ny
Greenish Warbler (*Phylloscopus trochiloides viridanus* Blyth.)	1	*Ixodes ricinus* 1 ny
Starling (*Sturnus vulgaris* L.)	2	*Ixodes ricinus* 1 la, 3 ny
		Ixodes arboricola 1 ♀, 2 la, 85 ny
July		
Redstart (*Phoenicurus phoenicurus* L.)	2 juv.	*Ixodes ricinus* 23 la, 9 ny
Icterine Warbler (*Hippolais icterina* Vieill.)	1	*Ixodes ricinus* 1 ny
Wood Warbler (*Phylloscopus sibilatrix* Bechst.)	1	*Ixodes ricinus* 1 la, 1 ny
Chaffinch (*Fringilla coelebs* L.)	1	*Ixodes ricinus* 2 la
August		
Blackbird (*Turdus merula* L.)	3 juv.	*Ixodes ricinus* 55 la, 10 ny
Redstart (*Phoenicurus phoenicurus* L.)	2	*Ixodes ricinus* 4 ny
Nightingale (*Luscinia luscinia* L.)	3	*Ixodes ricinus* 2 la, 4 ny
Icterine Warbler (*Hippolais icterina* Vieill.)	2	*Ixodes ricinus* 2 ny
Barred Warbler (*Sylvia nisoria* Bechst.)	1	*Ixodes ricinus* 1 ny
Garden Warbler (*Sylvia borin* Bodd.)	1	*Ixodes ricinus* 1 la
Whitethroat (*Sylvia communis* Lath.)	3	*Ixodes ricinus* 1 la, 5 ny
Willow Warbler (*Phylloscopus trochilus* L.)	4	*Ixodes ricinus* 2 la, 4 ny

Table 4 (continued).

	Number of positive birds	Species and number of specimens of ticks (la = larvae, ny = nymphs)
Wood Warbler (*Phylloscopus sibilatrix* Bechst.)	2	*Ixodes ricinus* 2 ny
Pied Flycatcher (*Ficedula hypoleuca* Pall.)	1	*Ixodes ricinus* 1 ny
Tree Pipit (*Anthus trivialis* L.)	2	*Ixodes ricinus* 1 la, 1 ny
Crossbill (*Loxia curvirostra* L.)	1	*Ixodes ricinus* 1 ny
September		
Marsh Tit (*Parus palustris* L.)	1	*Ixodes ricinus* 1 ny
Song Thrush (*Turdus philomelos* Brehm)	3	*Ixodes ricinus* 4 la, 6 ny
Redstart (*Phoenicurus phoenicurus* L.)	2	*Ixodes ricinus* 5 la, 3 ny
Robin (*Erithacus rubecula* L.)	2	*Ixodes ricinus* 17 la, 2 ny
Icterine Warbler (*Hippolais icterina* Vieill.)	1	*Ixodes ricinus* 3 la, 1 ny
Whitethroat (*Sylvia communis* Lath.)	2	*Ixodes ricinus* 4 la, 3 ny
Tree Pipit (*Anthus trivialis* L.)	2	*Ixodes ricinus* 4 ny

birds at Ottenby, viz. Mr. J. Ash (vide Arthur 1952) and Mr. I. Alnås who collects for the Zoological institute of Lund.

Mr. Ash carried out his work from August 27 to September 15, 1950. He examined 1.482 birds, belonging to 56 species, and of these 20 specimens of 13 species were infested by one or more ticks. The infestation rate was 1.3% which is less than that found by Myhrberg and Strömberg in September. *Ixodes ricinus* (nymphs and larvae) was present on 4 Redstarts (*Phoenicurus phoenicurus*), 2 Robins (*Erithacus rubecula*), 2 Blue-Headed Wagtails (*Motacilla flava*), 2 Lesser Whitethroats (*Sylvia curruca*), 1 Sparrow Hawk (*Accipiter nisus*), 1 Sedge Warbler (*Acrocephalus schoenobaenus*), 1 Tree Pipit (*Anthus trivialis*), 1 Meadow Pipit (*Anthus pratensis*), 1 Red-Spotted Bluethroat (*Luscinia svecia*), 1 White Wagtail (*Motacilla alba*), 1 Spotted Flycatcher (*Muscicapa striata*), 1 Willow Warbler (*Phylloscopus trochilus*), and 1 Whitethroat (*Sylvia communis*). *Haemaphysalis punctata* was found on two occasions: one adult female was taken from a White Wagtail and one nymph from a Redstart.

The material collected by Mr. Alnås in 1963 is listed in Table 4. Although not quantitatively collected it clearly shows that among the Passeriformes trapped at Ottenby many species carry ticks. Most specimens belong to *Ixodes ricinus*, but there are specimens of *I. arboricola* from a few birds and finally one nymph of *Hyalomma marginatum*.

11. Origin of ticks from migrating birds at Ottenby

Migrating individuals of the bird species listed as hosts above or in Tables 1–4 are as far as is known either Fennoscandian or originate from the western part of the USSR. No decision can be made as to where in this region the ticks have been picked up. Many of the birds may have become infested in Öland. This, however, is not likely to be the case with the ticks collected from migrating birds arriving from the South in March and April. At this time when many birds are coming in from their winter ranges, the free-living tick population in Sweden is still inactive. There are April records from Ottenby (Table 4) of ticks taken off several certain migrants, e.g. Tree Pipit (*Anthus trivialis*), Willow Warbler (*Phylloscopus trochilus*), Redstart (*Phoenicurus phoenicurus*), Robin (*Erithacus rubecula*), Song Thrush (*Turdus philomelos*), and Hedge Sparrow (*Prunella modularis*). The first three species have their winter quarters in tropical Africa, the Robin and the Song Thrush are met with in western Europe and the Mediterranean countries, while the Hedge Sparrow passes the winter in central and southern Europe.

It is well known that migrating birds moving north from their winter quarters stop at convenient places for rest and feeding. This evidently means good chances for the birds to pick up young stages of some species of ticks which are by this time active in southern and central Europe (Babos 1964). Tropical ticks seem to drop before the birds arrive in their nesting grounds in central and northern Europe, since no tropical ticks have been collected from migrants in this area.

Exclusive southeast migrants, such as the Lesser Whitethroat, also represent a group of birds whose transport of ticks is likely to occur under conditions which are easily recognized, in spite of the fact that these birds return to Sweden in May, when *Ixodes* are active. These Sylviinae arrive suddenly in large numbers and spread to their nesting territories immediately, rarely spending any length of time at the Ottenby Bird Station area. As seen from Table 4 (May) there are records of Lesser Whitethroat infested by *I. ricinus*.

Particularly interesting is the record of a fully-fed nymph of *Hyalomma marginatum* from a Tree Pipit. The typical form of the tick is widespread in southern Europe and south-western Asia and the specimen most probably was picked up somewhere in southern Europe by the bird en route from tropical Africa. There is a similar record of a species of *Hyalomma* being transported to Sweden by a White Wagtail (Schulze 1930, vide above p. 89). The same species has been collected from migrating birds in Germany (Kratz 1940), the British Isles (Thompson 1964) and Finland (Nuorteva & Hoogstraal 1963). In the eastern part of central Europe it seems to be fairly common that migrating birds carry specimens of *Hyalomma* (Babos 1964). So far as is known they all belong to the southern European subspecies and not to the closely related African taxon. Transportation of ticks by northbound migrating birds leaving Africa and southbound birds arriving in Africa was reported by Hoogstraal et al. (1961 a, b) and Hoogstraal et al. (1963) in Egypt.

Since the ticks stay on the hosts for feeding for some time (*I. ricinus*: 3–13 days, vide above), time is no obstacle to transportation.

12. Number and stages of ticks on birds

In most cases examined by Myhrberg – Strömberg and Alnås, only one or a few ticks were taken off each bird (cf. Tables 1–4). Exceptions are as follows: 2 Redstarts juv. from July 19 carried 8 larvae and 7 nymphs and 15 larvae and 2 nymphs respectively, a Blackbird on August 6 had 47 larvae and 2 nymphs all of *Ixodes ricinus*, while a Starling from May 13 carried 54 nymphs of *I. arboricola* and 1 nymph of *I. ricinus*. Finally, Mr. Alnås on August 6, 1962, trapped a young Blackbird from which 65 young specimens of *I. ricinus* were collected.

The large infestations are met with among bird species which search for their food mainly on the ground, while birds like the Sylviinae which take their food in trees and bushes are rarely infested by ticks.

It is well known that nymphs and larvae of *I. ricinus* are more common than adults on small mammals and that they are also found on the vast majority of birds. According to Ghibet, Zhmaeva and Berman (1965) larvae of *I. persulcatus* Schulze are rare on birds and seem to prefer small mammals. In the Kalinin area (Russia) they occurred on birds from the middle of June to the middle of July. Young nymphs were met with on small mammals but after the young birds had left their nests the nymphs were mainly found on birds.

In the material of 344 specimens of *I. ricinus* from 1962/63 there was a dominance of nymphs in April (5 larvae: 19 nymphs), May (27 larvae: 71 nymphs) and June (3 larvae: 7 nymphs), while in July (26: 11), August (62: 35) and September (40: 33) the larvae predominated. Adults are always very rare on birds. In the present investigation no adult *I. ricinus* was collected. Fed nymphs drop to the ground and moult and then the adults (mainly the female) usually mount large mammals, farm and domestic animals being the habitual hosts.

13. Tick infestation of migratory birds arriving in Finland

At two places in the south-western (Signildskär) and western (Valassaaret) parts of Fin-

land arriving birds were examined for ticks in the spring 1962 (Nuorteva & Hoogstraal 1963). At Signildskär 39 (2.1%) out of 1.928 birds examined were infested by *I. ricinus* (97 larvae/nymphs) and *Hyalomma marginatum* (1 nymph on an *Emberiza hortulana*). At Valassaaret 19 (2.6%) of 691 birds examined were infested by *I. ricinus* (31 larvae/nymphs) and *Hyalomma marginatum* (10 nymphs on one *Anthus trivialis*).

Of the birds examined the Passeriformes were the main tick bearers. To a very great extent the infested species are those listed from Ottenby in Tables 1–4. Additions are Ring Ouzel (*Turdus torquatus*), Red-Backed Shrike (*Lanius collurio*) and Ortolan Bunting (*Emberiza hortulana*).

14. Seasonal variation in tick infestation

Although various stages of ticks are found throughout the year, the biting activity is often concentrated in periods of optimal humidity and temperature conditions, i.e. spring – early summer and late summer – autumn. As regards *I. ricinus* this has been demonstrated by among others MacLeod (1939) and Milne (1945, 1947). The influence of season on the incidence of tick infestation varies from place to place. In parts of Europe the peaks are less marked and biting activity continues throughout the summer. In Sweden the conditions are still insufficiently known. Available data seem to indicate a variation of the activity in relation to latitude and summer climate.

No bimodal activity is clear from the present material of Ixodidae. There were no ticks in the Myhrberg – Strömberg material from July 31–August 6, but this may be due to the fact that most of the birds trapped during this period occur in open meadows and shores which are rarely invaded by ticks. On the other hand Brummer-Korvenkontio (1965) showed that in the Åland archipelago there was a minimum frequency of nymphs (and larvae) in the middle of the summer, while no biphasicity was established as regards adult ticks.

It is evident that local seasonal variation in the tick infestation may be a result of environmental conditions. But there is also a considerable variation in the infestation among the various bird species (cf. p. 93). Ghibet, Zhmaeva and Berman (1965) clearly demonstrated that the occurrence of immature ticks on birds was affected by the life habits, particularly the mode of feeding, of the birds. Their classification of bird species into three groups with regard to the birds being hosts of ticks, is a classification of the birds based upon their degree of contact with the tick habitat.

15. Tick infestation of birds under nesting conditions

The above material indicates that migrating birds carry ticks comparatively rarely. It is of some interest to compare this with the results of investigations on birds under nesting conditions. In eastern parts of central Europe birds seem to be the hosts of a considerable part of the larvae and nymphs of *Ixodes* (Korenberg 1962). In Czechoslovakia, Rosicky and Balat (1954) examined 109 species of birds and found *Ixodes* in 47 (43%). 48 specimens of *Anthus trivialis* were examined of which 65% were infested by *I. ricinus*, the mean infestation being 13.5 ticks.

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