FOLIA PARASITOLOGICA (PRAHA) 29: 85—95, 1982.

POSSIBLE ROLE OF BIRDS AND TICKS IN THE DISSEMINATION OF BHANJA VIRUS

Z. HUBÁLEK, V. ČERNÝ and P. RÖDL

Institute of Parasitology, Czechoslovak Academy of Sciences, Prague

DEDICATED TO ACADEMICIAN B. ROSICKÝ ON THE OCCASION OF HIS 60TH BIRTHDAY

Abstract. Several wild birds (4 *Fringilla coelebs*, 1 *Coccothraustes coccothraustes* and 2 *Erithacus rubecula*) were inoculated subcutaneously with Bhanja virus (BHAV). No clinical symptoms of infection were observed in any of the birds; a low viremia was demonstrated only in *C. coccothraustes* (2 and 4 days p.i.), seroconversion in all birds. BHAV was not isolated from organs 32 days p.i. Consequently, the tested birds do not seem to serve as "amplifying hosts" of BHAV. The paper includes a survey of geographic distribution of Bhanja virus and a list of its vectors. A hypothesis on the indirect dissemination of BHAV by birds by means of infected ticks is discussed. According to this hypothesis the European birds could be divided into 3 categories: 1. birds of the Palaearctic-African migration system in which African vectors of BHAV were detected and which could introduce into southern parts of the Palaearctic Region infected ticks from tropical savannahs of Africa (i.e., the biome of main BHAV distribution), 2. migratory birds, hosts of BHAV vectors occurring in southern Europe, which could transfer viruliferous ticks from South to Central Europe, 3. sedentary or migratory birds of steppe or forest — steppe biotopes, hosts of BHAV vectors, which could increase the virus circulation in natural foci either by dispersion of infected ticks to short distances or by a support of their life cycles.

Bhanja virus was first isolated from *Haemaphysalis intermedia* collected from paralyzed goats in India (Shah and Work 1969). In the following years, it was recorded in many countries of Central Africa, South Europe and southern regions of the USSR, and antibodies against this virus were detected in animals in North Africa, Central Europe and Iran (Table 1). A mass occurrence of BHAV seems to be related mostly with the savannah biome of tropical Africa (or steppes and forest-steppes in mild zone). The most common vectors are apparently ticks of the family Ixodidae parasitizing grazed domestic ruminants; the genera *Boophilus*, *Amblyomma* and *Hyalomma* in Africa, and *Haemaphysalis* and less frequently *Dermacentor*, *Rhipicephalus* and *Hyalomma* in other regions (Table 2).

With regard to the character of the geographic distribution of BHAV, some authors assume that it could be introduced by birds from tropical Africa to North Africa and Europe and from India or Africa to Central Asia (Verani et al. 1970, Vesenjak-Hirjan et al. 1977, Darwish et al. 1978). This hypothesis is discussed and analyzed in the present paper.

METHODS

Wild birds (4 *Fringilla coelebs*, 1 *Coccothraustes coccothraustes* and 2 *Erithacus rubecula*) were inoculated subcutaneously with 1 000 SMicLD$_{50}$ of Bhanja virus strain Bg 335/336 isolated from *Haemaphysalis sulcata* collected from sheep in Bulgaria (Pavlov et al. 1978) and passaged three times on suckling mice. Blood samples for serological examination and for detection of viremia (heparin 5 units/ml) were taken at given intervals from a wing vein of birds. Neutralization antibodies were detected in the sera by a test-tube method on Vero cells against 50 TCD$_{50}$ Bhanja virus. Viremia

Table 1. Geographic distribution of Bhanja virus

Continent	Country	Virus isolated from		References
		ticks	mammals	
ASIA	India	+	—	Shah and Work 1969
	USSR: Armenia	+	—	Semashko et al. 1973
	Azerbaijan	+	—	Gromashevsky et al. 1975
	Kirghizia	+	—	Karas et al. 1974
	Kazakhstan	+	—	Semashko et al. 1975
	Iran*	—	—	Saidi 1975
AFRICA	Nigeria	+	+	Causey et al. 1969 Kemp et al. 1974
	Cameroon	+	—	Vinograd et al. 1975
	Senegal	+	—	Robin et al. 1978
	Rep. Centrafricaine	+	—	Sureau et al. 1976
	Somalia	+	—	Butenko et al. 1979
	Uganda, Kenya*			
	Tanzania*	—	—	Butenko et al. 1979
	Egypt*, Tunisia*	—	—	Darwish et al. 1978
EUROPE	Italy	+	—	Verani et al. 1970
	Yugoslavia	+	—	Vesenjak—Hirjan et al. 1977
	Bulgaria	+	—	Pavlov et al. 1978
	Czechoslovakia*	—	—	Bárdoš et al. 1977
	France*	—	—	Chastel et al. 1980b
	Spain*	—	—	Chastel et al. 1980a

* The virus has not yet been isolated but the antibodies were detected in mammals

was demonstrated by i.c. inoculation of the blood into 1-2-day-old mice. The birds were sacrificed on day 32 p.i. and 10 % suspensions were made from their brains, livers, kidneys, hearts and lungs. The suspensions were inoculated intracerebrally into suckling mice. The methods used were described in detail in a previous paper (Hubálek and Rödl 1980).

While considering the possibility of virus transport by birds, ornithological manuals on the bionomy and character of seasonal migration of individual bird species (Peterson et al. 1966, Makatsch 1966, Moreau 1972 and others) and parasitological reports on findings of ticks on migratory and sedentary birds (Hoogstraal 1961, Hoogstraal et al. 1961, 1963, 1964, Nosek 1971, Saikku et al. 1971, Doss et al. 1974, Kaiser et al. 1974 and others) were consulted.

RESULTS AND DISCUSSION

No apparent clinical symptoms appeared in birds experimentally infected with Bhanja virus, but a seroconversion from negativity in preinoculation sera to relatively low titres (1 : 8 to 1 : 16) occurred in all of them on day 22 p.i. Viremia was demonstrated only in *C. coccothraustes* 43 hours p.i. (1 of the 6 inoculated mice died) and 4 days p.i. (2 of the 9 inoculated mice died), but not on day 7 p.i. The blood of other birds, collected also on days 2, 4 and 7 p.i., did not contain a detectable amount of the virus. Neither brain and other organs of all birds examined on day 32 p.i. contained Bhanja virus and no macroscopical changes in inner organs were observed.

The results indicate that the birds are no amplifying hosts (Bárdoš and Rosický 1979) of Bhanja virus. Of importance is the demonstration of viremia in *C. coccothraustes*, but it was very short and low and most probably insufficient for the infection of ticks sucking its blood. Semenov et al. (1973) did not demonstrate viremia in pigeons infected subcutaneously with 5 or 5 000 TCD_{50} of Bhanja virus and they did not manage

Table 2. Vectors of Bhanja virus, their hosts and geographic distribution

Tick species	Hosts[1]		Geographic distribution of the tick species[1]				The Bhanja virus isolation from the vector
	Mammals	Birds	Czechoslovakia	Southern Europe	Southern USSR	Tropical Africa	
Haemaphysalis intermedia Warburton et Nuttall	+	+	—	—	—	—	India (Shah and Work 1969)
H. punctata Canestrini et Fanzago	+	+	+	+	+	—	Italy, Yugoslavia, Bulgaria (Verani et al. 1970, Vesenjak-Hirjan et al. 1977, Pavlov et al. 1978)
H. sulcata Canestrini et Fanzago	+	+	—	+	+	—	Bulgaria (Pavlov et al. 1978)
Hyalomma detritum Schulze	+	(+)	—	+	+	—	Kazakhstan (Semashko et al. 1975)
H. marginatum Koch	+	+	(+)	+	+	+[2]	Kirghizia,[3] Somalia[4] (Karas et al. 1974, Butenko et al. 1979)
H. truncatum Koch	+	(+)	—	—	—	+	Nigeria, Senegal (Williams et al. 1972, Robin et al. 1978)
Dermacentor marginatus (Sulzer)	+	(+)	+	+	+	—	Armenia (Semashko et al. 1973)
Rhipicephalus bursa Canestrini et Fanzago	+	—	—	+	+	—	Azerbaijan, Italy (Gromashevsky et al. 1975, Verani et al. 1980)
Boophilus decoloratus (Koch)	+	—	—	—	—	+	Nigeria, Cameroon (Willams et al. 1972, Vinograd et al. 1975)
Amblyomma variegatum (Fabricius)	+	(+)	—	(+)	—	+	Senegal, Nigeria, Rep. CA (Williams et al. 1972, Robin et al. 1976, Sureau et al. 1976)

[1]) +, present; (+), occasionally or rarely present; —, absent
[2]) African subspecies *H. m. rufipes* Koch
[3]) as *H. plumbeum turanicum*
[4]) as *H. plumbeum impressum* (= *H. m. rufipes*)

to isolate the virus from inner organs on day 10 p.i. and later. This indicates, like our results, that probably not even chronic forms of BHAV infection, which might be of ecological importance, do occur in birds.

Nevertheless, it cannot be excluded that in case of a natural stress (malnutrition, energetical deficiency due to migration etc.) or concomitant infection some birds might respond to BHAV infection by a higher and longer viremia and longer persistence of

Table 3. Categories of birds with respect to a possible transport or circulation of Bhanja virus

Birds	Vectors found[1])	Category[2])
CICONIIFORMES		
Ardeidae		
Ardeola ibis (L.)	Bd	I
A. ralloides (Scopoli)	Hp	II
Ciconiidae		
Ciconia ciconia (L.)	Ht	I
FALCONIFORMES		
Aegypiidae		
Neophron percnopterus (L.)	Hm	I?[3])
Accipitridae		
Aquila chrysaetos (L.)	Hp, Hs, Hd	III
A. rapax Temminck	Hm	I?, III
Buteo buteo (L.)	Hp, Hm	I?, II, III
Circus aeruginosus (L.)	Hm	I?, II
C. cyaneus (L.)	Hp	II, III
C. macrourus (Gmelin)	Hmr	I
C. pygargus (L.)	Hp	II, III
Hieraetus pennatus (Gmelin)	Hm	I?, III
Milvus migrans (Boddaert)	Dm	II, III
Falconidae		
Falco cherrug Gray	Hm	I?, II, III
F. naumanni Fleischer	Hp, Hs, Hmm, Hmr	I, III
F. subbuteo L.	Hp	II, III
F. tinnunculus L.	Hp, Hmm, Hmr	I, II, III
GALLIFORMES		
Phasianidae		
Alectoris graeca (Meisner)	Hp, Hs, Hm	III
A. rufa (L.),	Hp	III
Coturnix coturnix (L.)	Hp, Hs, Hmm, Dm	II, III
Perdix perdix (L.)	Hp, Hm	III
Phasianus colchicus L.	Hp, Hs, Hm	III
GRUIFORMES		
Gruidae		
Anthropoides virgo (L.)	Hd, Hm	I?
Grus grus (L.)	Hm	I?
Rallidae		
Crex crex (L.)	Hp, Hs, Hd	II, III
Gallinula chloropus (L.)	Hp	II
Porzana porzana (L.)	Hmm, Hm	I?, II
Otididae		
Otis tarda L.	Hp	III
Tetrax tetrax L.	Hp, Hm	III
Burhinidae		
Burhinus oedicnemus (L.)	Hp, Hs, Hm, Dm	I?, II, III
CHARADRIIFORMES		
Charadriidae		
Charadrius alexandrinus L.	Hm	I?
C. dubius Scopoli	Hm	I?, II
Pluvialis apricaria (L.)	Hm	II
Vanellus vanellus (L.)	Hp, Hm	II
Scolopacidae		
Actitis hypoleucos (L.)	Hp	II

Table 3 — continued

Birds	Vectors found[1])	Category[2])
Numenius arquata (L.)	Hp	II
Philomachus pugnax (L.)	Hp	II
Scolopax rusticola L.	Hp, Hs	II
LARIFORMES		
Laridae		
Larus ridibundus L.	Hp	II
COLUMBIFORMES		
Columbidae		
Columba livia (Gmelin)	Hm	III
Streptopelia turtur (L.)	Hp, Hm, Dm	I?, II, III
STRIGIFORMES		
Strigidae		
Asio otus (L.)	Hp, Rb	III
Athene noctua (Scopoli)	Hs, Hm, Dm	III
Bubo bubo (L.)	Hm	III
Otus scops (L.)	Hmm, Hmr	I, II, III
CUCULIFORMES		
Cuculidae		
Cuculus canorus L.	Hp, Hmr	I, II, III
CAPRIMULGIFORMES		
Caprimulgidae		
Caprimulgus europaeus L.	Hp, Hs, Hm	I?, II, III
CORACIIFORMES		
Coraciidae		
Coracias garrulus L.	Hp, Hs, Hmm, Ht, Dm	I, II, III
Meropidae		
Merops apiaster L.	Hp, Hs, Hm, Dm	I?, II, III
Upupidae		
Upupa epops L.	Hp, Hs, Hd, Hmr, Dm	I, II, III
PASSERIFORMES		
Muscicapidae		
Ficedula albicollis (Temminck)	Hmr	I
F. hypoleuca (Pallas)	Hmr	I
Muscicapa striata (Pallas)	Hp, Hmm, Hmr	I?, II, III
Sylviidae		
Acrocephalus arundinaceus (L.)	Hp	II
A. schoenobaenus (L.)	Hp	II
Erythropygia galactotes (Temminck)	Hmr	I
Locustella luscinioides (Savi)	Hm	I?, II
Phylloscopus collybita (Vieillot)	Hp, Hmr	I, II
P. sibilatrix (Bechstein)	Hm	I?, II
P. trochilus (L.)	Hp, Hmm, Hmr	I, II
Sylvia atricapilla (L.)	Hmr	I
S. borin (Boddaert)	Hm	I?, II
S. cantillans (Pallas)	Hmr	I
S. communis Latham	Hp, Hs, Hmr	I, II, III
S. curruca (L.)	Hp, Hmr	I, II, III
S. hortensis (Gmelin)	Hmr	I
S. nisoria (Bechstein)	Hp, Hmr	I, II, III

Table 3 — continued

Birds	Vectors found[1])	Category[2])
Turdidae		
Erithacus rubecula (L.)	Hp, Hmr	II
Luscinia luscinia (L.)	Hp, Hs, Hmm, Hmr	I, II
L. megarhynchos Brehm	Hp, Hmr	I, II, III
L. svecica (L.)	Hp	II
Monticola saxatilis (L.)	Hp, Hs, Hmr, Dm	I, II, III
M. solitarius (L.)	Hp, Hs, Hmr	I, III
Oenanthe hispanica (L.)	Hs, Hmr	I, III
Oe. isabellina (Temminck)	Hp, Hs, Hmr	I, III
Oe. oenanthe (L.)	Hp, Hs, Hmr	I, II, III
Oe. pleschanka (Pallas)	Hp, Hs, Hmr	I, III
Phoenicurus ochruros (Gmelin)	Hm	II, III
Ph. phoenicurus (L.)	Hp, Hmm, Hmr	I, II
Saxicola rubetra (L.)	Hp, Hmm	II, III
S. torquata (L.)	Hp, Hmr	I, II, III
Turdus merula L.	Hp, Hs, Hd, Hmr	II, III
T. philomelos Brehm	Hp, Hs, Hmr, Dm	I, II, III
T. pilaris L.	Hp	II
T. viscivorus L.	Hp, Hm	II
Laniidae		
Lanius collurio L.	Hp, Hmr	I, II, III
L. minor Gmelin	Hp, Hs, Hm	I?, II, III
L. senator L.	Hmr	I
Hirundinidae		
Hirundo rustica L.	Hp, Hm	I?, II, III
Sittidae		
Sitta neumayer Michahelles	Hs, Hm	III
Fringillidae		
Carduelis cannabina (L.)	Hp, Hs, Hm	II, III
C. carduelis (L.)	Hmr	II
C. chloris (L.)	Hmr	II
Coccothraustes coccothraustes (L.)	Hp, Hm	II, III
Fringilla coelebs L.	Hp, Hmm, Hmr	II, III
Emberizidae		
Emberiza caesia Cretzschmar	Hmr	I
E. calandra L.	Hp, Hs, Hmr	II, III
E. cia L.	Hp, Hs, Hm	II, III
E. citrinella L.	Hp, Hm	III
E. hortulana L.	Hp, Hm	I? II, III
E. melanocephala Scopoli	Hp, Hm	III
Ploceidae		
Passer domesticus L.	Hp, Hm	III
P. hispaniolensis (Temminck)	Hp, Hm	III
P. montanus (L.)	Hp, Hs, Hd, Hm	III
Petronia petronia (L.)	Hm	III
Alaudidae		
Alauda arvensis L.	Hp, Hs, Hm	II, III
Calandrella cinerea (Gmelin)	Hp, Hm	I?, III
C. rufescens (Vieillot)	Hs, Hm, Dm	III
Eremophila alpestris (L.)	Hp, Dm	III
Galerida cristata (L.)	Hp, Hs, Hmr, Dm	III
Lullula arborea (L.)	Hp	II, III
Melanocorypha bimaculata (Ménétries)	Hp	III
M. calandra (L.)	Hp, Hs, Hm	III
Motacillidae		
Anthus campestris (L.)	Hp, Hs, Hmr	I, II, III

Table 3 — continued

Birds	Vectors found[1])	Category[2])
A. cervinus (Pallas)	Hmr, Av	I
A. pratensis (L.)	Hp	II
A. spinoletta (L.)	Hp	III
A. trivialis (L.)	Hp, Hs, Hmr, Av	I, II, III
Motacilla alba (L.)	Hp, Hmm, Hmr	I, II, III
M. cinerea Tunstall	Hp, Hm	I?, II
M. flava (L.)	Hp, Hs, Hmr	I, II, III
Sturnidae		
Sturnus vulgaris L.	Hp, Hs, Hm, Dm	II, III
S. roseus (L.)	Hp, Hs, Hm	III
Oriolidae		
Oriolus oriolus (L.)	Hm	I?, II
Corvidae		
Corvus corone cornix L.	Hp, Hmm, Dm	III
C. frugilegus L.	Hp, Hmm	III
C. monedula L.	Hp, Hmm	III
Garrulus glandarius (L.)	Hp, Hmm, Hd	III
Pica pica (L.)	Hp, Hs, Hmm, Dm	III

[1]) Excerpted from various sources, essentially from: Hoogstraal et al. (1961, 1963, 1964), Nosek (1971), Saikku et al. (1971), Doss et al. (1974), Kaiser et al. (1974).

Abbreviations: Hp = *Haemaphysalis punctata*, Hs = *H. sulcata*, Hd = *Hyalomma detritum*, Hm = *H. marginatum*, Hmm = *H. marginatum marginatum*, Hmr = *H. marginatum rufipes*, Ht = *H. truncatum*, Dm = *Dermacentor marginatus*, Rb = *Rhipicephalus bursa*, Bd = *Boophilus decoloratus*, Av = *Amblyomma variegatum*

[2]) Category I: The birds participating in the Palaearctic-African migration system (cf. Moreau 1972), proved hosts of the African vectors of Bhanja virus, which could make possible an intercontinental transport of infected vectors from tropical savannahs of Central Africa (3° to 16°N: Senegal, Nigeria, Cameroon, Republique Centrafricaine, Sudan, Somalia) to southern Europe and/or southern USSR.

Category II: Migratory birds which could make possible a short-distance (intracontinental) transport of viruliferous vectors from southern Europe to Czechoslovakia (Central Europe).

Category III: Sedentary or migratory birds of the steppe and forest-steppe habitats, which could support the life cycle of the vectors and the circulation of Bhanja virus in established foci of the virus infection in southern and/or central Europe.

[3]) "I?" means that the arrangement into the category I depends on whether the subspecies *H. m. rufipes* has been involved (incomplete data).

the virus in inner organs. Under these circumstances birds might be regarded as amplifying hosts of the virus directly supporting its circulation in nature. The experimental demonstration, however, is lacking.

Free-living (and also domestic) birds undoubtedly get into contact with Bhanja virus and acquire the infection through viruliferous ticks as it was demonstrated by Verani et al. (1970, 1977) in Italy. These authors detected specific haemagglutination-inhibiting antibodies against Bhanja virus in 2.2 % examined *Fringilla montifringilla*, 1.3 % *Coccothraustes coccothraustes*, 3.2 % *Turdus merula* and 5.7 % hens. The total serological positivity was 1.9 % of the 635 wild birds examined.

Apart from the possible carriership including latent infection and following activation of BHAV in birds, which is little probable, there is a possibility of indirect dissemination of BHAV by birds through the transport of infected ticks. This alternative hypothesis

on virus dissemination is more attractive for several reasons; though it is certainly very difficult to prove or disprove it. Considering the present knowledge of this problem from ornithological, parasitological and virological views, the birds can be divided into 3 categories (Table 3):

1. Birds which might introduce viruliferous ticks from tropical savannahs of Africa into South Europe or southern regions of the USSR. These are birds of the Palaearctic-African migration system in which African vectors of Bhanja virus were recorded, particularly some species of the families Cuculidae, Coraciidae, Upupidae, Muscicapidae, Sylviidae, Turdidae, Laniidae and Motacillidae.
2. Migratory birds, hosts of BHAV vectors occurring in South Europe, which might transfer infected ticks from South Europe to Central Europe, as some members of the families Accipitridae, Falconidae, Rallidae, Charadriidae, Scolopacidae, Laridae, Columbidae, Caprimulgidae, Meropidae, Sylviidae, Turdidae, Fringillidae, Emberizidae, Motacillidae and Oriolidae. All bird species used in our experiment belonged to this group.
3. Migratory and sedentary birds of steppe and forest-steppe biotopes, hosts of BHAV vectors, which might support virus circulation in foci in South and Central Europe either by a dispersion of viruliferous ticks to short distances or by supporting the life cycles of the vectors (increasing their abundance). These are members of the families Accipitridae, Phasianidae, Otididae, Columbidae, Strigidae, Sylviidae, Turdidae, Laniidae, Emberizidae, Ploceidae, Alaudidae, Motacillidae, Sturnidae and Corvidae.

The annual migration of birds from Africa to Eurasia in spring and in an opposite direction in autumn reaches a great extent. Moreau (1972) estimated that each spring about 3.75×10^9 birds migrate from Africa south of the Sahara to the Palaearctic Region. Some of the birds are infested with ticks, which are mostly of African origin in spring (*Hyalomma m. rufipes*) and of Eurasian origin in autumn (*Hyalomma m. marginatum*, *Ixodes ricinus* and others). During the spring migration through Egypt in 1960, 13.3 % of the 959 examined birds belonging to 29 species were infested with ticks (Hoogstraal et al. 1961), and in 1962, 6.5 % of 1774 birds belonging to 44 species were infested with ticks; among the 186 ticks 89.2 % were larvae and nymphs of *H. m. rufipes* (Hoogstraal et al. 1964). The average abundance of ectoparasites in infested birds was 1.0—5.6 ticks per bird, usually 2—3 ticks. The bird species most frequently and heavily infested with *H. m. rufipes* were *Falco tinnunculus, Upupa epops, Oenanthe oenathe, Oe. hispanica, Oe. isabellina, Erythropygia galactotes, Phoenicurus phoenicurus, Lanius senator*, somewhat less *Otus scops, Monticola saxatilis, Luscinia luscinia, Oe. pleschanka, Sylvia communis, S. atricapilla, S. cantillans, Ficedula hypoleuca* and *Anthus campestris*. In spring 1968, Kaiser et al. (1974) examined 22 015 migratory birds of 62 species in Cyprus. They found ticks in 0.8 % of them, mostly again larvae and nymphs of *H.m. rufipes* (95 % of all ticks); the larvae: nymph ratio was 1 : 2.5 and mean infestation was 4.3 ticks per bird. The most infested bird species were *Galerida cristata, F. tinnunculus, Anthus trivialis, A. cervinus, M. saxatilis* and *Turdus philomelos*. Nuorteva and Hoogstraal (1963) found *H.m. marginatum* ticks on birds coming in spring to Finland from South and Central Europe. The authors estimated that about 2 million ticks are introduced in Finland in this way every year. Saikku et al. (1971), who examined 3 070 migratory birds, found also African ticks, *H.m. rufipes*, in 1 specimen of *Oe. oenanthe* and 1 specimen of *Motacilla flava* in Finland.

Bhanja virus has hitherto been isolated only from adult ticks, not from their immature stages, whereas mostly larvae and nymphs occur on birds and imagoes only exceptionally. It should be noted, however, that the isolation experiments from immature stages of BHAV vectors have been carried out in a limited extent only. Moreover, by analogy with many tick-borne viruses, the transovarial and transstadial transfer of BHAV should be considered. Although this possibility has not been verified experimentally, it is partly indicated by the isolation of BHAV from unfed males of *Hyalomma truncatum* (Williams et al. 1972) and *Haemaphysalis sulcata* (Pavlov et al. 1978).

Undoubtedly some of the ticks transported by birds can be viruliferous. For example, Converse et al. (1974) isolated Bahig virus of the Tete group from larvae of *H. m. rufipes* collected from *Oe. oenanthe* migrating through Egypt to the North.

Considering Moreau's (1972) estimation of 3.75×10^9 migratory birds of the Palaearctic-African system and their mean 1 % infestation with 2—3 ticks (Hoogstraal et al. 1961, 1964, Kaiser et al. 1974), it can be supposed that up to 10^8 ticks are transported every spring from Africa to Eurasia. Let us suppose the minimum infection rate with BHAV in African ticks to be 1 : 1 000 in adults (Butenko et al. 1979 recorded 1 : 1 110 in *H. m. rufipes*) and 1 : 10 000 to 1 : 100 000 in nymphs and larvae. Then the annual transport from Africa to Eurasia would be about 10^3—10^4 larvae and nymphs infected with BHAV.

Of course, an introduction of infected tick by bird from Africa to a certain place of mild zone does not mean that a new natural focus will be formed here. This requires many other inner and outer factors (Rosický 1965, Hoogstraal 1973) enabling the introduced tick to survive, at least for a certain time, in the new and mostly adverse environment and disseminate the virus. Daniel et al. (1977) experimentally tested from this viewpoint 4 species of thermophilic ticks under conditions of biotopes in Czechoslovakia outside their geographic distribution and compared them with autochthonous species *Ixodes ricinus* and *Dermacentor reticulatus* in which complete development of all stages occurred in the experiment. *D. marginatus* and *H. punctata* developed to oviposition and nymph stage, whereas *Hyalomma anatolicum* and *Rhipicephalus sanguineus* attained only oviposition without further development. These results indicate that the statistical probability of the formation of new foci of arboviruses in South and Central Europe due to the introduction of infected exotic ticks will not be very high. In spite of this, this hypothesis should be further verified with respect to Bhanja virus.

ВОЗМОЖНАЯ РОЛЬ ПТИЦ И КЛЕЩЕЙ ПРИ РАСПРОСТРАНЕНИИ ВИРУСА BHANJA

З. Губалек, В. Черны и П. Редл

Резюме. Несколько диких воробьиных птиц (4 *Fringilla coelebs*, 1 *Coccothraustes coccothraustes*, 2 *Erithacus rubecula*) заражали подкожно вирусом Bhanja (BHAV). Клинические симптомы инфекции не наблюдали у никакой из птиц; слабая вирусемия обнаружена только у *Coccothraustes coccothraustes* (2 и 4 сутки после заражения), но конверсия сыворотки наблюдалась у всех птиц. Не удалось выделять BHAV из органов 32 дней после заражения. Следовательно, изучаемые птицы не служат „хозяевами-накопителями" BHAV. В работе приводится обзор географического распространения BHAV, список его векторов и подробно обсуждается гипотез о возможности распространения BHAV птицами косвенным путем, через зараженных клещей. По этому гипотезу европейские птицы разделяются на 3 категории: 1. птицы палеарктическо-африканской миграционной системы, у которых были найдены африканские векторы BHAV и которые могли бы интродуцировать содержащих вирус клещей из тропических саванн Африки (т. е. биома главного распространения BHAV) в южные части Палеарктики, 2. мигрирующие птицы, хозяева векторов BHAV, встречающихся в южной Европе, которые могли бы переносить содержащих вирус клещей из южной в средную Европу, 3. оседлые или мигрирующие птицы степных или лесостепных биотопов, хозяева векторов BHAV, которые могли бы поддерживать циркуляцию вируса в природных очагах, распространяя зараженных клещей на короткие расстояния или поддерживая жизненный цикл векторов.

REFERENCES

BÁRDOŠ V., HUBÁLEK Z., MITTERMAYER T., Bhanja virus serologic survey in Czechoslovakia. Folia parasit. (Praha) 24: 381, 1977.

—, ROSICKÝ B., A proposal for the evaluation of vertebrates as to their role in the circulation of arboviruses. Folia parasit. (Praha) 26: 89—91, 1979.

BUTENKO A. M., GROMASHEVSKY V. L., LVOV D. K., POPOV V. F., Isolation of Bhanja virus from *Hyalomma plumbeum impressum* ticks, collected in Somalia. Med. Parazitol. parazit. Bol. 48 (3): 37—39, 1979. (In Russian.)

CAUSEY O. R., KEMP G. E., MADBOULY

M. N., LEE V. H., Arbovirus surveillance in Nigeria. 1964—1967. Bull. Soc. Path. exot. 62: 249—253, 1969.

CHASTEL C., LAUNAY H., ROGUES G., BEAUCOURNU J. C., Infections à arbovirus en Espagne: Enquête sérologique chez les petits mammifères. Bull. Soc. Path. Exot. 73: 384—390, 1980a.

—, —, —, Le GOFF F., BEAUCOURNU J. C., Arbovirus infections in Brittany, France. Proc. Internat. Symp. New aspects in ecology of arboviruses: 413—425, 1980b.

CONVERSE J. D., HOOGSTRAAL H., MOUSSA M. I., STEK M., KAISER M. N., Bahig virus (Tete group) in naturally- and transovarially-infected *Hyalomma marginatum* ticks from Egypt and Italy. Arch. ges. Virusforsch. 46: 29—35, 1974.

DANIEL M., ČERNÝ V., HONZÁKOVÁ E., OLEJNÍČEK J., Possibilities of persistence in new biotopes of ticks imported by birds. Folia parasit. (Praha) 24: 47—54, 1977.

DARWISH M.A., HOOGSTRAAL H.,AMER T., A serological survey for Bhanja virus in humans, domestic mammals, and rats in Egypt. J. Egypt. Publ. Hlth. Ass. 53: 401—407, 1978.

DOSS M. A., FARR M. M., ROACH K. F., ANASTOS G., Ticks and tick-borne diseases. II. Hosts. Part 1—3. Index catalogue of medical and veterinary zoology. Special publication No 3, 1268 pp., 1974.

GROMASHEVSKY V. L., SKVORTSOVA T. M., NIKIFOROV L. P., KURBANOV M., Isolation of some arboviruses on the territory of the Turkmen SSR and the Azerbaijan SSR. Ekologia virusov, vyp. 3: 91—94, 1975. (In Russian.)

HOOGSTRAAL H., Migrating birds and their ectoparasites in relation to disease. East Afr. Med. J. 38: 221—226, 1961.

—, Viruses and ticks. In: A. J. Gibbs (Ed.), Viruses and invertebrates, North-Holland Publ. Co., Amsterdam: 349—390, 1973.

—, KAISER M. N., TRAYLOR M. A., GABER S., GUINDY E., Ticks (Ixodoidea) on birds migrating from Africa to Europe and Asia. Bull. WHO 24: 197—212, 1961.

—, —, —, GUINDY E., GABER S., Ticks (Ixodidae) on birds migrating from Europe and Asia to Africa, 1959—1961. Bull. WHO 28: 235—262, 1963.

—, TRAYLOR M. A., GABER S., MALAKATIS G., GUINDY E., HELMY I.,Ticks (Ixodidae) on migrating birds in Egypt, spring and fall 1962. Bull. WHO 30: 355—367, 1964.

HUBÁLEK Z., RÖDL P., Experimental infection of wild birds with Bhanja virus. Proc. Internat. Symp. New aspects in ecology of arboviruses: 361—369, 1980.

KAISER M. N., HOOGSTRAAL H., WATSON G. E., Ticks (Ixodoidea) on migrating birds in Cyprus, fall 1967 and spring 1968, and epidemiological considerations. Bull. ent. Res. 64: 97—110, 1974.

KARAS F. R., VARGINA S. G., OSIPOVA N. Z., STEBLYANKO S. N., GROMASHEVSKY V. L., SKVORTSOVA T. M., USMANOV R. K., Isolation of Bhanja virus from *Hyalomma plumbeum* ticks in the south-western climatic zone of Kirghizia. Ekologia virusov 2: 124—126, 1974. (In Russian.)

KEMP G. E., CAUSEY O. R., SETZER H. W., MOORE D. L., Isolation of viruses from wild mammals in West Africa, 1966—1970, J. Wildlife Dis. 10: 279—293, 1974.

MAKATSCH W., Wir bestimmen die Vögel Europas. Neumann Verlag, Radebeul, 508 pp., 1966.

MOREAU R. E., The Palaearctic-African bird migration systems. Academic Press, London-New York, 1972.

NOSEK J., The ecology, bionomics, and behaviour of *Haemaphysalis* (*Aboimisalis*) *punctata* tick in Central Europe. Z. Parasitenk. 37: 198—210, 1971.

NUORTEVA P., HOOGSTRAAL H., The incidence of ticks (Ixodoidea, Ixodidae) on migratory birds arriving in Finland during the spring of 1962. Ann. Med. exp. Fenn. 41: 457—468, 1963.

PAVLOV P., ROSICKÝ B., HUBÁLEK Z., DANIEL M., BÁRDOŠ V., MINÁŘ J., JUŘICOVÁ Z., Isolation of Bhanja virus from ticks of the genus *Haemaphysalis* in southeast Bulgaria and presence of antibodies in pastured sheep. Folia parasit. (Praha) 25: 67—73, 1978.

PETERSON R., MOUNTFORT G., HOLLOM P. A. D., A field guide to the birds of Britain and Europe. Collins Publ., London, 1966.

ROBIN Y., CAMICAS J. L., JAN C., HEME G., CORNET M., VALADE M., Ecology of tick arboviruses in arid areas of Senegal. Proc. Symp. Transcontinental connections of migratory birds and their role in the distribution of arboviruses, Novosibirsk, pp. 209 to 212, 1978.

ROSICKÝ B., Types of animal movements and their influence on natural foci of diseases. In: B. Rosický, K. Heyberger (Eds.), Theoretical questions of natural foci of diseases. Publ. House Czech. Acad. Sci., Prague: 151—162, 1965.

SAIDI S., Survey for antibodies to arboviruses in various animals in Iran. Abstr. 3rd Internat. Congr. Virol., Madrid, 3: 274, 1975.

SAIKKU P., ULMANEN I., BRUMMER-KORVENKONTIO M., Ticks (Ixodidae) on migratory birds in Finland. Acta ent. fenn. 28: 46—51, 1971.

SEMASHKO I. V., DOBRITSA P. G., TEMIRBEKOV Z. T., CHUNIKHIN S. P., ILYAZOVA I. N., IVANOVA G. P., First detection of Bhanja virus in southern Kazakhstan, Tez. Konf. Vopr. Med. Virusol., Moscow, p. 354, 1975. (In Russian.)

—, MATEVOSYAN K. SH., PIVANOVA G. P., CHUMAKOV M. P., Isolation of Bhanja virus from *Dermacentor marginatus* ticks collected from sheep in the area of lake Sevan, Armenia. Meditsinskaya Virusol. 21 (2): 160—164, 1973. (In Russian.)

SEMENOV B. F., CHUNIKHIN S. P., KARMYSHEVA V. Ya., YAKOVLEVA N. I., Chronic forms of arbovirus infections in birds. 1. Experiments with Sindbis, West Nile, Bhanja and Sicilian mosquito fever viruses. Vest. Akad. med. Nauk SSSR no. 2: 79—83, 1973. (In Russian.)

SHAH K. V., WORK T. H., Bhanja virus: A new arbovirus from ticks *Haemaphysalis intermedia* Warburton and Nuttall, 1909, in Orissa, India. Ind. J. med. Res. 57: 793—798, 1969.

SUREAU P., CORNET J. P., GERMAIN M., CAMICAS J. L., ROBIN Y., Enquète sur les arbovirus transmis par les tiques en République Centrafricaine (1973—1974). Isolement des virus Dugbe, CHF/Congo, Jos et Bhanja. Bull. Soc. path. exot. 69: 28—33, 1976.

VERANI P., BALDUCCI M., LOPES M. C., Isolation of Bhanja virus in Italy and serologic evidence of its distribution in man and animals of different Italian regions. Folia parasit. (Praha) 17: 367—374, 1970.

—, LOPES M. C., BALDUCCI M., QUERCIOLI A., BERNARDINI E., Survey for antibodies to arboviruses in man and animals in Italy. IV. Serological status of human beings and animals in a central Italian region (Grosseto province). Ann. Sclavo 19: 951 to 958, 1977.

—, —, CIUFOLINI M. G., NICOLETTI L., AMADUCCI L., FRATIGLIONI L., PACI P., LEONCINI F., BALDUCCI M., Studies on the occurrence of tick-borne encephalitis in Italy. Proc. Internat. Symp. New aspects in ecology of arboviruses: 65—74, 1980.

VESENJAK—HIRJAN J., CALISHER C. H., BRUDNJAK Z., TOVORNIK D., ŠKRTIČ N., LAZUICK J. S., Isolation of Bhanja virus from ticks in Yugoslavia. Am. J. trop. Med. Hyg. 26: 1003—1008, 1977.

VINOGRAD I. A., KRASOVSKAYA I. A., SIDOROVA G. A., SAZONOV A. A., BOCHE R., ROBIN G., RAVISSE P., MENO J., LVOV D. K., GONIDEC L., Isolation of Bhanja arbovirus from *Boophilus decoloratus* ticks in Cameroon. Vopr. Virusol. 20: 63—67, 1975. (In Russian.)

WILLIAMS R. W., CAUSEY O. R., KEMP G. E., Ixodid ticks from domestic livestock in Ibadan, Nigeria as carriers of viral agents. J. med. Entomol. 9: 443—445, 1972.

Received 20 May 1981.

Z. H., Parasitologický ústav ČSAV, Flemingovo n. 2, 166 32 Praha 6, ČSSR

FOLIA PARASITOLOGICA (PRAHA) 29: 95—96, 1982.

HIRSTIONYSSUS APODEMI ZUEVSKY, 1970 AND EULAELAPS OUDEMANSI TURK, 1945 (ACARINA, PARASITIFORMES) — FIRST RECORDS IN CZECHOSLOVAKIA

Two species of gamasoid mites, *Hirstionyssus apodemi* Zuevsky, 1970 and *Eulaelaps oudemansi* Turk, 1945, were recorded for the first time in Czechoslovakia. The material examined (41 428 arthropod specimens) was collected from 3 022 small mammals caught in western and southern Bohemia.

Hirstionyssus apodemi Zuevsky, 1970

Material examined — *Apodemus sylvaticus:* 2 ♀♀, Vranín (district of Třeboň), 6 Oct. 1976; 1 ♀, Lhota (district of Třeboň), 17 Nov. 1976; 1 ♀, Apolénský vrch (district of Tachov), 14 June 1977; 3 ♀♀, Vranín, 26 July 1977; 2 ♀♀, Sytno (district of Tachov), 23 August 1977; 2 ♀♀, Apolénský vrch, 23 August 1977; 3 ♀♀, Hoštka (district of Tachov), 24 August 1977; 1 ♀, Hoštka, 25 August 1977; 1 ♀, Sytno, 13 Sept. 1977; 1 ♀, Sytno, 14 Sept. 1977; 1 ♀, Lhota, 11 Oct. 1977; 2 ♀♀, Apolénský vrch, 25 Oct. 1977; 3 ♀♀, Hoštka, 27 Oct. 1977; 1 ♀, Hoštka, 28 Oct. 1977. — *Microtus arvalis:* 1 ♀, Sytno, 23 Sept. 1976; 1 ♀, Vranín, 5 July 1978.

In older literature, the mites of the genus *Hirstionyssus* parasitic in exoanthropic small mammals were recorded under the invalid name *H. musculi* (Johnston, 1849). According to Zuevsky (Zool. zh. 49: 1342—1348, 1970), two morphologically and ecologically different species have been reported under this name: *H.*