



# Update on Tick-Borne Bacterial Diseases in Travelers

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## Abstract

**Purpose of Review** Ticks are the second most important vectors of infectious diseases after mosquitoes worldwide. The growth of international tourism including in rural and remote places increasingly exposes travelers to tick bite. Our aim was to review the main tick-borne infectious diseases reported in travelers in the past 5 years.

**Recent Findings** In recent years, tick-borne bacterial diseases have emerged in travelers including spotted fever group (SFG) rickettsioses, borrelioses, and diseases caused by bacteria of the Anaplasmataceae family.

**Summary** African tick-bite fever, due to *Rickettsia africae*, is the most frequent agent reported in travelers returned from Sub-Saharan areas. Other SFG agents are increasingly reported in travelers, and clinicians should be aware of them. Lyme disease can be misdiagnosed in Southern countries. Organisms causing tick-borne relapsing fever are neglected pathogens worldwide, and reports in travelers have allowed the description of new species. Infections due to Anaplasmataceae bacteria are more rarely described in travelers, but a new species of *Neoehrlichia* has recently been detected in a traveler. The treatment of these infections relies on doxycycline, and travelers should be informed before the trip about prevention measures against tick bites.

**Keywords** *Rickettsia* · Tick-borne diseases · Traveler · *Borrelia* · *Ehrlichia* · *Anaplasma*

## Introduction

Ticks are hematophagous arthropods considered the second most common vector of human pathogens after mosquitoes [1]. Two families of ticks can transmit a wide range of pathogens: Ixodidae (hard ticks) and Argasidae (soft ticks). Ticks from all regions carry specific pathogens that may remain unknown to clinicians from other parts of the world. This is an important issue when dealing with travel medicine. International travel has continuously increased during the past 5 years, reaching a total of 1235 million international tourist arrivals worldwide in 2016 [2]. International tourism represents a significant source of income for developing countries, and the trend is forecast to rise. Besides tourism, other reasons

for travel include business or studies, visiting friends and relatives, and military or foreign aid development. In recent years, international adventure tourism has also increased. This type of tourism leads to potential human exploration into previously untouched tick habitats, resulting in an increased risk of tick bites and thus of tick-borne bacterial, viral, and parasitic diseases. This review will focus on bacterial tick-borne infections including rickettsioses, ehrlichioses, anaplasmoses, and borrelioses [1].

Rickettsioses are obligate intracellular bacteria of the order Rickettsiales. The taxonomy of these pathogens has been widely reorganized in recent years due to the discovery of many new species. Rickettsioses are associated with arthropods mainly lice, ticks, mites, and fleas, which may act as vectors or reservoirs of the bacteria. Most of spotted fever group (SFG) are transmitted to the animal or human host during the blood meal of hard ticks [3].

The Anaplasmataceae family comprises *Ehrlichia chaffeensis*, the agent of human monocytotropic ehrlichiosis (HME) transmitted by *Amblyomma* ticks, *Anaplasma phagocytophilum*, the agent of human granulocytic anaplasmosis (HGA), transmitted by *Ixodes* ticks, and “*Candidatus Neoehrlichia mikurensis*,” the agent of *Neoehrlichioses* in

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humans, mainly transmitted by *Ixodes* ticks [4•]. The family also includes the genera *Neorickettsia*, *Wolbachia*, *Aegyptianella*, and “*Candidatus Xenohalictis*” [1].

The genus *Borrelia* is composed of helical-shaped bacteria within the phylum of Spirochetes. They cause two groups of human diseases: Lyme disease transmitted by hard ticks of the *Ixodes* genus [5], and relapsing fevers, transmitted by soft ticks or by lice [6]. Lyme disease is caused by the *Borrelia burgdorferi* sensu lato complex, transmitted by *Ixodes* ticks in North America and Eurasia. Tick-borne relapsing fever borrelioses are transmitted through the bite of soft ticks of the genus *Ornithodoros* and cause recurrent fever linked to spirochaetemia [7].

Here, we review all the recent data about tick-borne bacterial diseases in travelers in the literature during the past 5 years.

## Tick-Borne Rickettsioses

The importance of rickettsioses as potential causes of fever in travelers became apparent in the 2000s thanks to a report by Jensenius et al. describing more than 450 rickettsioses cases in travelers [8]. Then, the GeoSentinel Surveillance Network detailed the clinical features of 280 cases of rickettsial infections in international travelers [9]. SFG rickettsioses, transmitted by ticks, were the most frequent rickettsioses in travelers, with a hundred of cases of African tick-bite fever (ATBF) caused by *Rickettsia africae*, reported in the literature between 2004 and 2013 [3•]. Since then, ATBF remains the most frequent reported rickettsiosis in travelers from Sub-Saharan Africa, particularly southern Africa, and the West Indies [3•]. Other emerging SFG rickettsioses of interest in travelers comprise Mediterranean spotted fever (MSF) caused by *Rickettsia conorii* and emerging pathogens like *Rickettsia massiliae*, *Rickettsia sibirica mongolitimonae*, *Rickettsia slovaca*, and new SFG *Rickettsia* strain Tenjiku01.

### African Tick-Bite Fever

ATBF has been reported to be the second most frequent cause of fever after malaria in travelers returning from Sub-Saharan Africa [3•, 10]. Its agent, *Rickettsia africae*, is transmitted through the bite of ticks of the genus *Amblyomma* (mainly *Amblyomma hebraum* and *Amblyomma variegatum*). These ticks are aggressive in that they will attack people, and the percentage of ticks carrying *R. africae* is high—up to 100% in some places—which is responsible for clusters of patients presenting with multiple inoculation eschars [11]. The usual clinical presentation is a febrile vesicular or maculo-papular rash with one or more inoculation eschars [3]. During the last 5 years, 14 case reports have been published describing ATBF

in travelers [11, 12••, 13–24]. The majority of patients were men (75%), with a mean age of 40 years, and three were children between 7 and 16 years. Ten patients returned from South Africa and two from Zimbabwe (Table 1). The first report of ATBF in a traveler returning from Uganda was published in 2016 in a Slovenian patient [23]. The other countries of travel were Kenya and Tanzania [16, 20]. The most frequent reason for travel was tourism, except for two patients who were working in development and aid programs (Table 1). All patients shared the risk factor of game-hunting safari or just walking in a rural game-hunting reserve. Among the 14 published ATBF cases in travelers, three had multiple eschars, as previously described in ATBF [15, 22]. Eschars were predominantly localized in the lower limbs (ankle, knee, or hips). Six patients presented with a maculo-papular rash confirming that this feature is not systematically present in ATBF. When the eschar was localized in lower limbs, regional lymphadenopathy (inguinal) was frequently present (Table 1). Neurological involvement has been described in ATBF, including encephalopathy and peripheral neuropathy [3•]. A recent case reported a painful sacral syndrome in a young woman, predominating in the limb where the patient was bitten [12••]. This complication seems to be mediated by both direct damage by the pathogen and immune-mediated mechanism since the patient failed to respond to antibiotic treatment but improved after steroid therapy [12••]. Also, the first case of retinitis and panuveitis associated with ATBF in a traveler has been described in 2016 [19].

ATBF has long been considered a benign disease with spontaneous remission, but the neurologic and ophthalmic cases [12••, 19], along with a past case of myocarditis [25] demonstrate the possibility of complications in a minority of untreated patients. The diagnosis was made for most patients by PCR detection of *Rickettsia africae* in an eschar biopsy or on eschar swab, which is a relatively non-invasive method for patients and has good sensitivity [3•]. Serology can be positive in the convalescent phase, and cross reactivity can be seen with other SFG rickettsioses. When ATBF is clinically suspected in adults and children > 8 years, antimicrobial therapy with doxycycline 200 mg daily should be started for a 7-day duration [3•]. For children < 8 years, and adults who are allergic to tetracyclines, azithromycin is an alternative. Doxycycline remains however the treatment of choice in severe cases in children.

### Mediterranean Spotted Fever

MSF is caused by *Rickettsia conorii conorii* and is transmitted by the brown tick *Rhipicephalus sanguineus*, which feeds mainly on dogs and incidentally bites humans, particularly during the warm seasons [3•]. The main geographical distribution of the disease is the Mediterranean region, but the agent has also been detected in ticks in Sub-

**Table 1** Case reports describing ATBF in travelers

Ref. No.	Year	Sex	Age	Country of travel	Purpose of travel	Incubation	Clinical presentation	Nationality
[12••]	2014	F	40	Zimbabwe	Medical Doctor dispensary	—*	Fever, eschar ankle, painful sacral syndrome	Italia
[13]	2015	M	63	South Africa	Safari in a game reserve	2 weeks	Fever, myalgia, rash, chills night sweats, arthralgias, eschar hip	The USA
[14]	2014	M	76	South Africa	Hunting	2 days	Fever, headache, myalgia, eschar right leg, lymphadenopathy of the groin	The USA
[15]	2015	M	66	South Africa	—*	—*	Fever, headache, myalgia, odynophagia, 3 eschar on the inferior limb (groin and ankle)	France
[16]	2016	F	30	Tanzania	Developmental aid project, hiking in a rural game reserve	—*	Fever, chills headache, myalgia eschar ankle, inguinal lymphadenopathy	Austria
[17]	2015	F	15	South Africa	Game hunting	10 days	Fever, headache and myalgia, popliteal eschar, inguinal lymphadenopathy	The USA
[19]	2016	F	67	Africa	Game hunting	—*	Fever, malaise, eschar in right elbow and rash, maculo-papular petechial rash of the lower limbs panuveitis and retinitis	The USA
[11]	2015	M	51	South Africa	Safari	10 days	Fever chills, maculo-papular rash, eschar on right nipple	Poland
[18]	2013	M	47	South Africa	Safari	*	Fever headache and malaise, popliteal eschar, inguinal lymphadenopathy	Germany
[20]	2016	M	30	Kenya	Safari	*	Papular rash on chest, fatigue, chills, sweats, fever, eschar left foot, lymphadenopathy of the groin	The USA
[23]	2016	M	29	Uganda	—*	5 days	Fever chills, abdominal eschar and axillar lymphadenopathy, papular rash	Slovenia
[21]	2017	M	56	South Africa	Safari	1 day	Fever ad sweats, thoracic eschar	Sweden
		M	41	Zimbabwe	Visiting rural environments		Eschar right leg, fever, fatigue and lymphadenopathy of the groin	Sweden
[22]	2017	M	7	South Africa	Game hunting Safari	7 days	Fever, headache and myalgia, papular rash, multiple eschars	Spain
		M	8	South Africa	Game hunting Safari	—*	Fever, headache myalgias, multiple eschar and regional lymphadenopathy	
		M	16	South Africa	Game hunting Safari	—*		
[24]	2017	M	53	South Africa	Safari	9 days	Skin lesion, malaise myalgia, inguinal and popliteal lymphadenopathy, popliteal eschar	The USA

\*Data not available

Saharan Africa, even overlapping the distribution of *R. africae*. Clinical presentation includes inoculation eschar, fever, and maculo-papular rash (Fig. 1), which can be purpuric in severe cases. The disease is more severe

than ATBF, with possible multi-organ failures in patients with comorbidities such as diabetes or disordered alcohol use [3•]. A series of cases have been described between 2004 and 2014 in patients returning from North Africa



**Fig. 1** Rash caused by *R. conorii conorii*

(Morocco or Algeria), Spain, and Sub-Saharan Africa [3•]. Recently, a severe case with multiple cutaneous necroses due to vasculitis has been reported from the coastal belt of Sri Lanka, in a previously healthy 39-year-old woman [26]. *R. conorii* serology was highly positive. However, since the diagnosis was made by serology, it is unknown whether this severe presentation of the disease was due to *Rickettsia conorii conorii* or to another agent of SFG rickettsiosis present in this region (*Rickettsia conorii subsp. indica*, the agent of Indian tick typhus) [27]. Nonetheless, this report indicates a potential threat for travelers in this tourist area.

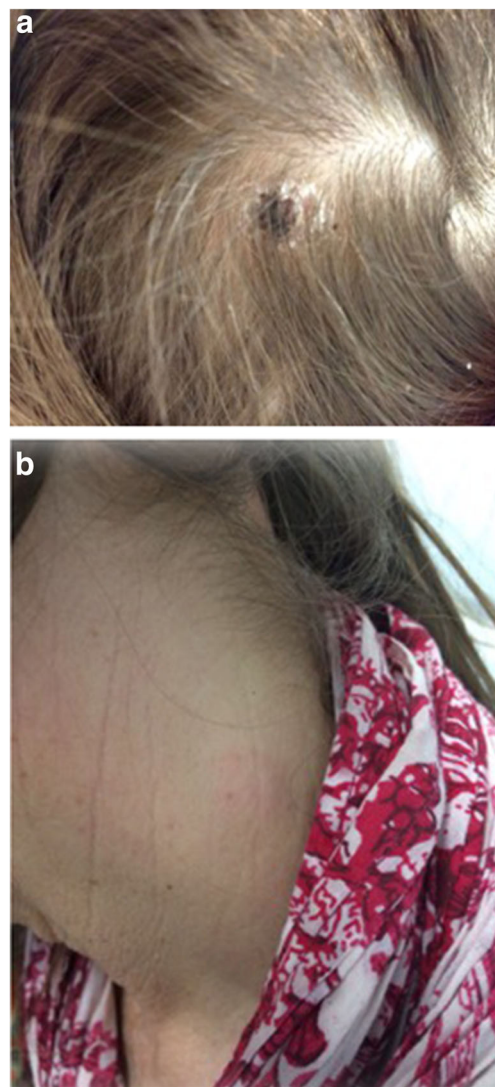
Also recently published is a fatal case of MSF in a 55-year-old Portuguese traveler who visited Brazil and developed fever and petechial rash followed by hemorrhage and shock [28]. No eschar was identified in this patient. Vero cell culture of blood and molecular identification revealed that the disease was caused by *Rickettsia conorii conorii* [28]. There is a potential publication bias in the fact that only severe or fatal cases have been published during the last few years, but the severity should remind clinicians that clinical suspicion of MSF necessitates prompt doxycycline treatment.

### Other Tick-Borne Rickettsioses

*Rickettsia massiliae* is a SFG pathogen that was first described in 1993. It is an emerging disease which has been reported to date in Romania, Argentina, Italia, and France [29–32]. *Rhipicephalus* ticks are the main vectors of transmission. The clinical presentation is comparable with other SFG rickettsioses, but a case of “scalp eschar and neck lymphadenopathy” has also been reported [30]. Chochlakis et al. recently reported the first case of *Rickettsia massiliae* infection in Greece in a patient arriving from the UK, who presented with an eschar on the arm, a macular rash, headache, fever, and malaise [33].

*Rickettsia sibirica mongolitimonae* is another emerging SFG rickettsiosis, which is present in the Mediterranean area. Cases have been reported in travelers from the Mediterranean area and Sub-Saharan Africa [3•, 34]. Recently, Ramos et al. reported six cases of *Rickettsia sibirica mongolitimonae* infection in the tourist region of Alicante (Mediterranean coast of Spain) [35]. Patients presented with eschar, fever, myalgia, rash, and lymphangitis associated with regional lymphadenopathy [35] (Fig. 2). The evolution was favorable for all patients after treatment with doxycycline. Clinicians should consider this diagnosis for patients with eschar, rash, fever, and lymphadenopathy, who visited the highly frequented Mediterranean coast of Spain.

*Rickettsia slovaca* is one of the agents of scalp eschar and neck lymphadenopathy (SENLAT) syndrome in Europe. Such syndrome was previously referred to as tick-borne lymphadenitis (TIBOLA) or *Demacentor*-borne necrosis erythema and



**Fig. 2** SENLAT syndrome. **a** Scalp eschar. **b** Neck lymphadenitis



lymphadenopathy (DEBONEL). *Rickettsia slovaca* infection is transmitted by ticks of the genus *Dermacentor* that feed preferentially on ungulate mammals or dogs but incidentally bite humans on the scalp. The clinical presentation consists in low-grade fever, scalp eschar, fatigue, and neck lymphadenopathy (Fig. 3a, b). A recent case of SENLAT due to *Rickettsia slovaca* transmitted by a *Dermacentor marginatus* tick was reported in the UK [36]. This case was unusual because *Dermacentor marginatus* ticks are not native to the UK and no previous case of *Rickettsia slovaca* has been described there. The patient has not traveled, but he reported recent contacts with many visitors from Spain, Czech Republic, Romania, and the Netherlands, which are countries where *Dermacentor marginatus* ticks are present [36].

Recently, Takajo et al. reported a possible case of a new SFG rickettsiosis in a Japanese traveler returning from India [37]. The 60-year-old woman returned to Japan after travel to Bangalore (southern India) where she went camping and had many outdoors activities. She developed fever, malaise, and rash 1-day after return. She also had thrombocytopenia, elevated liver enzymes, and splenomegaly. No eschar was noted. PCR on blood was positive for SFG *Rickettsia*, and the sequencing of PCR products yielded a profile different from any known *Rickettsia* sp. and was designed as strain Tenjiku01, phylogenetically closely related to *Rickettsia honei* [37]. *Rickettsia honei* is another SFG *Rickettsia*, which has been described in Asia and can cause severe manifestations including pneumonia and encephalitis [27]. This case illustrates how travel medicine can help to contribute to the knowledge of emerging infectious diseases.



**Fig. 3** Eschar of the breast and lymphangitis caused by *Rickettsia sibirica mongolitimonae* in a French patient

## Tick-Borne Borrelioses

### Lyme Disease

Lyme disease is caused by *Borrelia burgdorferi* sensu lato species, including *Borrelia burgdorferi* sensu stricto, *Borrelia afzelii*, *Borrelia garinii*, *Borrelia bavariensis*, and *Borrelia spielmanii*. These bacteria are transmitted by hard ticks of the genus *Ixodes* (*Ixodes ricinus* in Europe and *Ixodes scapularis* in North America). Because the culture of *Borrelia* sensu lato group is fastidious and the infection fails to induce spirochetemia, the diagnosis is mainly made by serology. The primary infection is characterized by a localized rash surrounding the tick bite, called “erythema migrans” (EM), with an annular aspect and a secondary centrifugal extension. Disseminated infection occurs when EM is left untreated and consists of lymphocytoma, neurological, rheumatologic, or late dermatological signs (achrodermatitis chronica atrophicans). Clinical aspects of the disease can vary depending on the region of the tick bite because of different *Borrelia* genospecies distributions throughout the world. For example, lymphocytoma and neurologic disease is more frequent in Europe than in the USA [5]. These features are particularly useful since clinical presentation of Lyme disease in travelers can be a diagnostic challenge. An areolar lymphocytoma has been reported in a child 5 weeks after returning in the USA from Germany [38]. The parents of the child recalled an EM-like lesion in the right flank 1 week after a tick bite in Germany. Serologic testing including European species of *Borrelia* was positive, and the child was successfully treated by amoxicillin [38].

Because Lyme disease is mainly prevalent in the northern part of the Northern hemisphere, EM can be misdiagnosed in non-endemic areas. For instance, a 26-year-old American woman from Virginia, USA, was initially treated by an emergency physician with ceftriaxone for cellulitis in Bogota [39]. In fact, 1 week before arriving in Colombia, she had been bitten by a tick while walking in the woods in Virginia. When provided with this recent history, an infectious disease practitioner made the diagnosis of EM and started doxycycline. Diagnosis of EM in a Brazilian traveler returning from camping in Germany where she sustained a tick bite has also been reported [40]. A similar case of EM in a Japanese traveler returning from the USA was reported by Kutsuna et al. [41].

In Australia, the first case of imported neuroborreliosis in a woman traveling back from Lithuania was reported in 2015 [42]. The patient suffered from an 8-month history of somnolence, confusion, and diplopia. The symptoms had begun after travel in Lithuania where she was bitten by a tick and developed an EM-like lesion. Meningoencephalitis was diagnosed by cerebrospinal fluid (CSF) monocytosis and positive IgG to antigen of *Borrelia burgdorferi* sensu lato in the serum and CSF. The outcome was favorable after parenteral ceftriaxone

treatment. *Borrelia burgdorferi* sensu lato has never been detected in ticks in Australia, thus, Lyme disease is not considered endemic, and the only cases are reported in travelers [43].

A case of *Borrelia burgdorferi* and *Babesia* co-infection after a tick bite in the USA has been reported in a 68-year-old American woman while visiting Paris [44]. The patient presented with typical EM, followed by high-grade fever, thrombocytopenia, and hepatitis; her blood smear was positive for *Babesia microti*, confirmed by 18S RNA sequencing. The outcome was favorable after treatment with amoxicillin, atovaquone, and clindamycin and followed by azithromycin and atovaquone. Clinicians should be reminded of the possibility of co-infection with several other tick-borne agents (parasites; *Babesia* sp. or viruses; tick-borne encephalitis virus (TBE)) when diagnosing a tick-borne bacterial disease in a traveler from the Northern hemisphere.

### Tick-Borne Relapsing Fevers

Tick-borne relapsing fevers (TBRF) are acute febrile illnesses, characterized by multiple recurrences of fever, headache, myalgia, and arthralgia that have been described worldwide [45]. Clinically, it is impossible to distinguish from other febrile illnesses like malaria. The diagnosis can be made by microscopic examination of blood smear during febrile episodes or by molecular methods [46]. Unfortunately, diagnostic tools are often lacking in developing countries like Africa, where diagnoses in travelers may contribute to a better understanding of local disease epidemiology.

Goutier et al. has reported 11 cases of TBRF due to *Borrelia crociduræ* in travelers returning from Senegal to France [46]. Among them, four patients presented with meningitis and two had encephalitis [46]. *Borrelia crociduræ* was detected in blood and CSF of patients from 16S RNA PCR and sequencing [46]. Duration of travel varied from 15 to 53 days, and three patients reported no insect bite. Travel accommodation varied from hotel to family homes. One patient experienced up to five episodes of fever before he was diagnosed. The outcome was favorable for all patients after treatment with ceftriaxone or doxycycline. A previous case of TBRF with meningoencephalitis due to *Borrelia crociduræ* in a Belgian traveler returning from Senegal was published in 2012 [47]. Both reports suggest that severe neurologic complications of TBRF can occur more frequently than previously thought [46]. Animal studies have shown that *B. crociduræ* has the capacity to cross the blood-brain barrier and is the most neurotropic of TBRF-associated *Borrelia* species [48].

Neurotropism of TBRF agents is also illustrated by an atypical clinical presentation of TBRF that was reported by Socolovschi et al. in a French traveler returning from Ethiopia [49•]. A 77-year-old woman presented with a necrotic eschar at a tick-bite site in the arm, surrounded by an erythematous lesion and pain in the left upper limb. This episode was treated

like ATBF with doxycycline, but the patient came back 3 weeks later with a C8 radiculopathy. After PCR identification of *Borrelia* sp. in CSF and positive serology using *Borrelia burgdorferi* sensu lato antigens, the patient was treated as a neuroborreliosis by ceftriaxone. Unfortunately, species-level identification was not achieved in this case. This case demonstrated that radiculopathy in travelers can also be a sign of TBRF.

Recently, Fingerle et al. reported a case of TBRF due to a new species of *Borrelia* in a 26-year-old woman returning from South Africa to Germany [50]. The patient reported an arthropod bite on her foot during a walk in the Kalahari Desert in South Africa. A rash developed at the bite site and fever began 8 days later. Blood smears detected spirochetes, and molecular detection and sequencing enabled identification of a new species named "*Candidatus Borrelia kalaharica*." The patient was treated with doxycycline, but due to suspicion of a Jarisch-Herxheimer reaction after an increase in body temperature, steroid treatment was added and the patient subsequently improved [50].

*Borrelia miyamotoi* is an emerging agent of TBRF, which was first described in Japan in 1995 [51, 52]. The particularity of this agent is that it is not transmitted like other TBRF bacteria by soft ticks but by hard ticks. The first case of human infection was reported in Russia in 2011. A case of possible co-infection with *Borrelia miyamotoi* and *Borrelia burgdorferi* has been reported by a Japanese team in a 63-year-old American man living in Japan returning from Minnesota where he was bitten by a tick. The clinical presentation included EM in the right buttock, and was associated with high-grade fever, a feature which is not typical of Lyme disease, but of *Borrelia miyamotoi*. The Western blot showed seroreactivity to both *Borrelia burgdorferi* sensu lato antigen and relapsing fever borreliae antigens [51], so that the authors considered the patient as having a co-infection. The outcome was favorable after doxycycline treatment.

### Anaplasmosis and Neoehrlichiosis

*Anaplasma phagocytophilum*, the agent of HGA, is transmitted by *Ixodes* ticks and cases have been reported in the USA, Europe, and Asia. Three cases of HGA in travelers have been reported in the literature before 2014 [3•]. All cases presented with fever, headache, or joint pain, and the outcome was good after doxycycline treatment. Severe complications of this infection are rare (septic shock, acute renal failure, rhabdomyolysis) and have not been reported in travelers. One more case in a traveler has been reported in 2015, in an American woman living in Austria returning from Connecticut, USA, where she was bitten by a tick [53]. She developed fever, fatigue and joint pain, leukopenia, and thrombocytopenia 1 week after the tick bite. A qPCR targeting the 16S RNA gene of

*A. phagocytophilum* was positive on blood and serology was positive for IgM. The evolution was also favorable with doxycycline treatment. Co-infection was investigated but resulted negative (*Babesia*, *Borrelia burgdorferi*, *Rickettsia* sp.). Another case of HGA has very recently been reported by an Israeli team in an 85-year-old Christian pilgrim coming from New Hampshire [54].

*Candidatus Neoehrlichia mikurensis* is an emerging tick-borne pathogen that has never been cultured to date [55•]. It has been detected in ticks and rodents in Europe, Asia, and Africa. The first case of human infection was reported in Europe in 2010 [4•]. The clinical presentation is severe in immunocompromised patients, and asymptomatic carriage has been reported in the immunocompetent. In 2016, an Austrian team reported the first case of symptomatic infection in a 30-year-old healthy woman returning from Tanzania, attributed to a new agent of this genus [56]. The patient had a 3-week history of fever, chills, myalgia, headache, and night sweats. She came back 4 weeks before hospitalization from a vacation to Tanzania where she was in contact with a prosimian (a primitive primate such as the lemur and loris) but recalled no tick bite. 16S RNA broad-range PCR was positive on the blood, and the sequencing showed a 98% homology with “*Candidatus Neoehrlichia lotoris*” and 97% with *Candidatus Neoehrlichia mikurensis* [56]. As a consequence, the authors chose to name this agent “*Candidatus Neoehrlichia Tanzania*.” The patient recovered after treatment with doxycycline, which continued until blood PCR became negative. *Candidatus Neoehrlichia mikurensis* has been detected in ticks in Nigeria, suggesting that *Neoehrlichia* are emerging pathogens in Africa.

A single case of human monocytic ehrlichiosis (HME) in a 32-year-old traveler due to *Ehrlichia chaffeensis* was reported in 2013, and no new case has been published since then [10].

## Conclusion: Prevention of Tick-Borne Diseases in Travelers

The most important prevention measure in travelers is to avoid tick bites during travel. The major prevention measures include wearing long trousers tucked into boots and using tick repellents. Tick repellent can be used topically (*N,N*-diethyl-*m*-toluamide (DEET)) and by impregnation of clothes with permethrin [3•]. If a tick bite occurs during travel, the tick should be immediately removed because the risk of infection increases with the attachment duration [3•]. Rickettsioses, borrelioses, and members of the Anaplasmatacea are all susceptible to doxycycline, so that malaria prophylaxis with doxycycline may be protective for tick-borne bacterial infections [56]. The only available data regarding this hypothesis relates to the prevention of scrub typhus, which favors efficacy of this strategy. Within the 14 travelers reported in this

review with ATBF, two had malaria prophylaxis with atovaquone-proguanil, two did not take any prophylaxis, and information was unavailable for the other patients. In travelers going to Sub-Saharan Africa, our choice is to prefer doxycycline to prevent malaria, ATBF, TBRE, and neoehrlichiosis.

## Compliance with Ethical Standards

**Conflict of Interest** The authors declare that they have no conflict of interest.

**Human and Animal Rights and Informed Consent** This article does not contain any studies with human or animal subjects performed by any of the authors.

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