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A travel medicine guide to arthropods of medical importance

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Arthropod-transmitted diseases cause enormous morbidity, mortality, and economic losses worldwide. Global surveillance data on many of these diseases are reviewed elsewhere in this issue. Although residents of North America seem most concerned about encounters with hematophagous arthropods and vector-borne agents while traveling abroad, they are also at risk in their own neighborhoods and during journeys throughout their own continent. For example, 9862 human cases of disease caused by West Nile virus were reported in the United States during 2003, 2866 of which were neuroinvasive [1]. Lyme disease cases numbered 23,763 during 2002 [2]. In contrast, of the 1337 cases of malaria reported in 2002, all but five were acquired abroad [3]. Although autochthonous cases of leishmaniasis are rare in the United States, the Centers for Disease Control and Prevention dispenses sodium stibogluconate to treat an average of 30 to 40 imported cases annually.

Those who travel for business and pleasure may put themselves at particular risk by their choices of destination, season of travel, accommodations, and activities. Military personnel constitute a special class of traveler, and because they often cannot exercise avoidance, they face particularly elevated risks of vector-borne disease. More than 350 American

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troops have acquired leishmaniasis while serving in Iraq from May 2002 to January 2004 [4].

This article describes clinically relevant aspects of the biology, ecology, and epidemiology of the main kinds of arthropods that directly injure people or transmit infections. Guidance is offered to clinicians so they might better educate and advise travelers how to protect themselves, and evaluate and manage complaints by travelers on their return.

Arthropods as the cause of direct injury or as vectors

Arthropods can cause diverse problems for the traveler. At one end of the spectrum, they may cause distress simply by making their presence known. The characteristic whine produced by the beating wings of certain mosquitoes, for example, causes some people to panic and lose sleep, even if none land and feed. At the opposite extreme are situations in which insects and ticks transmit pathogenic agents that result in considerable illness and death. Between these extremes are various arthropods that infest, feed on, or otherwise harass travelers. The interval of contact may be fleeting (as the bite of a mosquito), more prolonged (as bot fly larvae developing in the skin), or chronic (as from a resident and perpetuating population of scabies mites or lice on the body).

Several reference works are available to guide the clinician in serving the traveler. Background information on vector-borne diseases and statistics on case reports are provided by Internet sites maintained by the Centers for Disease Control and Prevention [5]. Descriptions of the vectors and vector-borne pathogens are detailed in infectious disease and medical entomology texts [6,7], and in printed and online image atlases [8,9].

Pathogen transmission

Transmission of a vector-borne agent, in general, requires the presence of an arthropod that is competent (ie, it must be physiologically able to acquire, maintain, and transmit a suitable quantum of the infectious agent). To serve as a suitable vector, it must also satisfy requirements of vectorial capacity. As such, it must survive long enough for the pathogen to develop or multiply within it, be abundant where and when the reservoir hosts are abundant, and focus it's feeding on hosts that are effective reservoirs [10]. An arthropod that has ingested pathogens from its host is considered infected. If the arthropod is not a competent vector, the pathogens fail to survive, develop, or multiply, or otherwise fail to be transmitted to a new host. A vector becomes infectious solely after the pathogens have developed or multiplied and journeyed to their relevant point of egress from the vector (eg, the saliva for Lyme disease spirochetes and malarial sporozoites, the hindgut for louse-borne typhus rickettsiae).

Generally, people acquire vector-borne pathogens while being fed on by the vector. Most often, the pathogenic agents are within the vector's saliva injected directly into the skin. In this manner, people become inoculated with agents as diverse as the sporozoites of malaria, the virions of arboviruses, and the bacterial agent of Lyme disease. The infectious particles are either mainlined directly into blood vessels or deposited into perivascular tissue in the skin. Infectious larvae, such as the nematode agents of lymphatic filariasis and onchocerciasis, forcibly escape from the mouthparts of their feeding mosquito and black fly hosts, respectively. A droplet of insect hemolymph on the skin protects these tiny worms for a fleeting moment until they enter the wound left by the insect's mouthparts, or they become stranded and die. The metacyclic trypomastigotes of American trypanosomiasis, in contrast, are passed not in the saliva, but in the feces of their triatomine vectors. The host is infected when these protozoa are scratched or rubbed into the wound or mucus membranes. Similarly, the agents of louse-borne typhus and louse-borne relapsing fever are passed in the feces of their body louse vectors. These kinds of agents must develop or proliferate within the vector's tissues, and in these cases the arthropod vector serves to effect biologic transmission.

Various pathogens may contaminate the mouthparts, gut, or body of an insect or tick, whether or not these arthropods engage in hematophagy. Microbes carried in this manner may then be passed on without any development or proliferation in the vector, a process termed "mechanical" transmission. Certain other agents rely on other mechanisms for transmission (eg, ingestion of the infected vector by the vertebrate host), but these are beyond the limited scope of this article.

Modes of encounter

Arthropods approach and molest people to find shelter and sustenance, or to deposit the eggs that give rise to their progeny. They locate hosts mainly by detecting body heat, and by following olfactory cues (carbon dioxide; lactic acid; and for certain African *Anopheles,* a particular constituent of foot odor), and visual cues (size, shape, color, pattern, and movement). Even where and when vector-borne pathogens are transmitted intensely, relatively few potential vectors are infected, and even fewer are infectious (terms defined previously).

They feed on blood mainly to nourish themselves and to acquire proteins needed for egg development. The agents they transmit to vertebrate hosts can also burden the vector or enhance the likelihood of their transmission. The malaria parasite may compel the infected mosquito to probe more extensively, the plague bacillus causes the flea to regurgitate, and filariae may reduce the flight range and longevity of their fly vectors.

The chance of encountering a potential vector is a function of geography, season, and the specific activities in which the traveler engages. Whatever the chances of this encounter, because a relatively small proportion of potential vectors in any site are likely to be infected, the risk of acquiring vector-borne disease from any single encounter is further reduced. The aggregate chance of infection, however, rises with each new contact. Generally, a single bite from an infectious vector is sufficient to transmit viral, bacterial, or protozoan infections and, because these pathogens multiply in the human host, one bite can produce disease. One mosquito bite can lead to malaria, one sand fly bite to leishmaniasis, and one tick bite to a case of tick-borne encephalitis or Lyme disease.

The vectors of filariasis inoculate the vertebrate host with motile larvae, each of which matures into one adult worm nearly a year later. Each mated female worm may produce many thousands of tiny motile microfilariae daily that then course through the host's skin or blood to await carriage by another vector. Generally, a person in a filariasis endemic region must suffer thousands of bites during a period of several years to acquire enough infective bites to cause demonstrable infection and clinical disease. The short-term traveler very rarely suffers clinical filariasis. An exception is loiasis where one adult worm can cause symptoms.

The brief moment during which flies (including mosquitoes) bite is sufficient to infect the new host. In comparison, ticks feed more slowly. Whereas the argasid (soft) ticks may complete their feeding in a matter of minutes, the ixodid (hard) ticks remain attached and feed for 3 or more days. Several kinds of pathogenic agents (eg, the spirochete of Lyme disease) do not appear in the tick's saliva until the tick has been feeding for about 2 days. Early recognition and removal of the feeding tick in such cases may preclude transmission before it becomes infectious.

Within North America, visitors can encounter an impressive array of potential vectors and vector-borne agents. Mosquitoes and ticks provide the most prominent threats to residents and travelers, alike. The *Culex* mosquitoes that serve as the main vectors of West Nile virus exploit the foul water within the ubiquitous storm water catch basins lining urban and suburban streets, and in clogged roof gutters, rain-filled trash barrels and toys, and in disused swimming pools. Although *Culex* mosquitoes tend to feed preferentially on birds, people serve as occasional hosts for these and other kinds of mosquitoes. The efficiency and intensity of West Nile virus transmission is evidenced by the rapid coast-to-coast spread of this epidemic. Prevalence of infection within mosquito and bird populations, and risk for people rises through the summer, peaking in late summer and into early autumn. Other mosquito-borne arboviruses, such as the agents of eastern equine and St. Louis encephalitis, follow a similar seasonal pattern, but are more restricted in their geographic ranges.

Deer ticks and the agents they vector (particularly those causing Lyme disease and human babesiosis) were, until recently, restricted to a few defined foci in New England, the upper Midwest, and California. The burgeoning deer population throughout the eastern United States now supports dense deer tick populations, and consequently, enhances risk of these deer tick–transmitted infections in suburban and rural areas. Risk to people is seasonal, and corresponds to the host-seeking activities of the nymphal ticks in late spring through early summer, and of the adult ticks in late autumn and in the springtime.

Visits abroad provide the traveler with diverse and often unfamiliar risks. Close relatives of American deer ticks occur throughout much of Europe and Asia, where they transmit agents causing Lyme disease and tick-borne encephalitis. Mosquitoes become of particular concern in regions endemic for malaria and dengue. Occasional autochthonous cases of malaria occur in the United States, mainly through the actions of imported infected vectors (airport malaria) or local transmission by indigenous vectors that acquired infection from a returning traveler [11]. Although the phlebotomine sand flies of the tropics and subtropics are diminutive and often go unnoticed, the leishmanial infections they can transmit often lead to disfiguring or significant illness.

Any kind of arthropod, whether a vector or not, can survive and flourish only within particular ecologic constraints. Whereas most insects and ticks tolerate an impressive range in temperature, humidity, and day length conditions, other kinds are restricted by narrow tolerances. Human head lice, for instance, thrive only when ambient conditions match those within an inch or so of the human scalp. Reduced daylight hours (such as during the approach of autumn) cause certain temperate *Culex* mosquitoes to enter physiologic diapause (a resting stage, similar to hibernation). When reared under such short day length conditions, the adults feed on sugars rather than blood, and seek shelter in which they may survive through the winter. Increasing daylight hours in the spring or warming temperatures stimulate these mosquitoes to seek blood meals and their ovaries to produce eggs. Such an innate timing mechanism may also restrict these mosquitoes to certain latitudes.

Just as the ambient temperature constrains the distribution of a vector, it may also limit the geographic range of the pathogen. The *Anopheles* mosquito vectors of malaria may survive and prosper at ambient temperatures at or below 20°C, but such low temperatures dramatically extend the extrinsic incubation period of the malarial agent within the vector. Few mosquitoes survive long enough to transmit sporozoites to a new host. At temperatures below 15°C and 18°C, *Plasmodium vivax* and *P falciparum*, respectively, fail to develop within the vector. The presence of the vector does not necessarily connote risk for certain vector-borne diseases. These temperature considerations limit the distribution of such infections as a function of latitude and altitude.

As with temperature, rainfall and other climatic conditions profoundly influence the seasonal abundance of many kinds of vectors and the transmission intensity of vector-borne disease. Ground depressions inundated by seasonal rains or run-off from snowmelt may give rise to prodigious populations of mosquitoes. The main malaria vectors in portions of sub-Saharan Africa may be scarce, and transmission of malaria virtually nonexistent, until after the rains have begun each year. Elsewhere, the main and ancillary vectors maintain transmission throughout the year.

The frequency of vector-host contact depends on the extent to which their activity overlaps. Each kind of mosquito exhibits its own characteristic daily pattern of host seeking. *Culex* and *Anopheles* mosquitoes, in general, seek hosts at night, whereas many *Aedes* attack at midday. Others time their meals at hours near dawn and dusk. Night-active mosquitoes may readily take blood meals from sleeping human hosts. Although certain *Anopheles* feed almost exclusively on hosts while outdoors, others readily enter dwellings in search of their meals. Other outdoor biters, such as black flies and tsetse flies, may accidentally enter a dwelling, but once inside they pursue escape rather than any available hosts. Soft (argasid) ticks, bed bugs, and certain mites remain close to their host's nest and await the predictable, often nightly, return of their meals. Bedrooms, thereby, serve as foci for these pests.

The work environment and quality of the accommodations profoundly influence the kinds of vectors encountered, and the frequency of such contact. Travelers staying within well-constructed and air-conditioned urban hotels and offices face minimal risks of encountering such pests while inside. They lose these protections, however, when outside such privileged confines. Those staying in less stellar surroundings face increased risks. Accommodations lacking window screens in malarious regions are best avoided, or the traveler should take care to use a bed net properly (preferably one that has been treated with an insecticide) and to take malarial prophylaxis. Even with screens and nets, the indoor environment may not be free of mosquito risk. Populations of the yellow fever mosquito, *Aedes aegypti,* can perpetuate without venturing outdoors. Their aquatic immature stages develop in water jugs and vases, and the adults of this mosquito feed and rest indoors. Primitive accommodations pose even greater risks. Thatched roofs in the American tropics and subtropics offer harborage for the cone-nosed or kissing bugs (triatomines) that transmit American trypanosomiasis.

Arthropods of public health importance may actively seek out a host for the few seconds needed to acquire a meal of blood or to lay their eggs, may passively lay in wait for the host to approach them, or may take up residence on or in the host's body. In the latter case, the arthropods are provided with unlimited food, security, and a likely means of contacting additional hosts. The following discussion briefly illustrates the ecology of the more prominent arthropods that may burden the traveler.

Chronic and obligate parasites of human beings

People serve as the sole source of food and shelter for a few kinds of parasitic arthropods. Some of these cause chronic infestations, and the etiologic agents may accompany the traveler home. Most prominent of these are the scabies-inducing *Sarcoptes* mites and the three kinds of human-lice. *Sarcoptes scabiei* is a colorless, ovoid mite less than 1 mm long that excavates sinuous burrows in the stratum corneum. Adult females occasionally emerge from these burrows and crawl over the surface of the skin. Infestations are most prevalent in the tropics, and crowding promotes outbreaks. Transmission mainly depends on direct contact between hosts. Because these mites succumb in about 2 days when isolated from a human host, fomite transmission (eg, through contaminated clothing or bedding) is rarely important. Infestations are generally asymptomatic for a month or more, until cell-mediated and humoral immune hypersensitivity responses to the mite's saliva and feces cause inflammatory skin lesions. Pruritus, particularly when affecting one or more close contacts, raises suspicion of scabies. Definitive diagnosis should rest on discovery of the mites or their eggs extracted from their burrows (most often found in the web spaces between the fingers) or in skin scrapings or by epidermal shave biopsy. A single application of permethrin is usually sufficient to eliminate living mites, but persisting mite antigens may continue to provoke allergic reactions for many months.

Human beings are also the sole hosts for head lice (*Pediculus capitis*), body lice (*Pediculus humanus*), and pubic lice (*Pthirus pubis*). These wingless insects feed only on blood and infest the surface of the skin and hair; they are incapable of burrowing. Head lice infest children more often than adults. Transmission likely occurs by direct head-to-head contact with an infested person; fomites are relatively unimportant. Body lice, in contrast, mainly infest the indigent, and sequester in the seams of clothing worn for extended intervals. Body lice are transmitted mainly by direct contact, and by shared bedding and clothing. Pubic lice mainly infest sexually promiscuous people, and are primarily transmitted venereally. They are concentrated on the hair of the pubis, and occasionally also on hair ornamenting the face and axillae and on eyelashes. Infestations of head lice are generally asymptomatic, but transient pruritus may occur from allergic reactions to their saliva. Bites of body lice and pubic lice tend to cause more intense pruritus and an erythematous maculopapular rash. Body lice, but not head lice or pubic lice, may serve as vectors for louse-borne typhus, louse-borne relapsing fever, and trench fever. Body lice and these pathogenic agents are most frequently encountered in areas of civil strife, in prisons where inmates do not bathe or change clothes frequently, and in homeless shelters. Few business or leisure travelers are likely to encounter body lice or their pathogens. Diagnoses and treatment of louse infestations should rest on demonstrating a live louse, and not on the finding of their presumptive eggs. Lice and their eggs may be removed from hair by mechanical means, but applications of pediculicides are often necessary to eliminate the infestations [12]. Pyrethrins and synthetic pyrethroids are generally efficacious for killing lice, but they tend not to affect the eggs. Malathion formulations seem effective for killing louse eggs and lice that are resistant to pyrethroids. Body lice can be eliminated in most cases simply by bathing and changing to well-laundered clothes. Lice are usually host specific, so lice of lower animals very rarely, if ever, bite people.

Parasites staying for limited, but extended, intervals

An array of arthropods that are obligate parasites for part of their development may occasionally attack people. Whereas most kinds of fleas attack only briefly, the chigoe flea, *Tunga penetrans*, can infest travelers who walk barefoot or in sandals in rural sites in Africa, Latin America, and India. The fertilized female penetrates the stratum corneum of the skin, and beneath the margins of toenails, and causes an enlarging furuncular lesion as the flea swells to the size of a pea. Although the lesion is generally self-limiting, it is painful and may cause sloughing of skin. The developing flea should be removed as soon as possible by means of a sterile needle.

Many kinds of hard (ixodid) ticks readily feed on people. These ticks tend to quest passively and await a passing host to sweep them off of vegetation. A host's warmth and exhaled carbon dioxide stimulates other ticks to approach from a short distance. These ticks imbed their harpoon-like mouthparts into the skin and remain in place and feed for several days. Once engorged, they drop off and wander away. Hiking in woods or through high grass enhances contact with these ticks, some of which may transmit agents of Lyme disease, human babesiosis, Rocky Mountain spotted fever, and various kinds of tick-borne encephalitis viruses. Some level of protection is afforded by pretreatment of clothing with permethrin. Hikers should inspect their bodies each day to locate and remove attached ticks before they transmit pathogens. Fine-tipped forceps are most suitable to grasp and withdraw the ticks by the base of their mouthparts.

Larvae of several kinds of flies invade wounds or intact tissue to produce myiasis (maggot infestation), usually in skin, but sometimes in body orifices, intestine, eye, or other organs. In Central and South America, the human bot fly *(Dermatobia hominis)* attaches her eggs to the body of a mosquito or other flying insect that serves as a vehicle to carry them to a large mammal. Heat from the mammal causes larvae to hatch, drop from their transport host, and penetrate the mammal's skin. The larvae mature in a boil-like lesion, and after about a month of development, they emerge and pupate away from the host. In parts of Africa, female tumbu flies, *Cordylobia anthropophaga*, deposit numerous eggs on urine- or sweat-contaminated clothing. Clothing that has been washed in a stream and dried in the open serve as attractive and suitable substrates. The eggs embryonate within 2 days and remain viable for about 2 weeks. Contact with warm, moist skin stimulates the larvae to emerge, penetrate skin, and form boils from which larvae emerge within 9 days. Travelers should ensure that their clothes are ironed if they have been traditionally laundered in endemic regions. In

North America, horse botflies, *Gasterophilus intestinalis*, deposit their eggs on the flanks of horses. A human rider's warm, moist, bare leg substitutes for the horse's tongue to stimulate larvae to hatch and penetrate skin. Larvae migrate through the skin, producing narrow raised pruritic tunnels. Covering the lesion with an occlusive ointment or gentle pressure is often sufficient to coax the air-breathing larvae to emerge. In other cases, surgical excision is required.

Larvae of about 20 kinds of trombiculid mites (chiggers) normally feed on reptiles, small mammals, and birds, but attack people, causing dermatitis and occasionally transmitting pathogens. These tiny (approximately 0.25 mm long) mites climb and cluster on grass tips and wait for a passing host. They tend to attach to skin around the waist or wherever clothing is constricting, and feed for several days on host tissues liquefied by their saliva. The harvest mite of Europe and the American chigger of North America cause seasonal risk in late summer through early autumn. Their bites cause intense itching and wheals and pustules within hours of feeding, but they do not serve as vectors. In parts of Asia, several kinds of chiggers transmit the rickettsial agent of scrub typhus, but the bites themselves are insignificant. Insect repellents on skin and clothing provide some protection from chigger attack.

Nest parasites

Various kinds of arthropods sequester in and around the nests of their vertebrate hosts, and patiently wait for their meals to return. Because people's homes (or hotels, hostels, dormitories) are, functionally, glorified nests, it should not be surprising to find these inhabited by parasitic arthropods. Chief among these are bedbugs, soft (argasid) ticks, and cone-nosed (triatomine) bugs, all of which feed exclusively on blood.

Bedbugs and their close relatives inhabit nests and roosts of birds and bats worldwide, and feed on these and other hosts. During the past few years, the cosmopolitan bedbugs have become increasingly recognized as a pest in hovels, homes, and high-class hotels throughout North America and Europe. These flattened, wingless bugs hide in cracks and crevices, often in the bed frame and mattress, and emerge at night to feed painlessly on their sleeping victims. They feed frequently when hosts are available, but can survive nearly a year between meals if necessary. Although not known to transmit infectious agents to people, the reactions to the saliva from these bugs can be exceedingly distressing. Infestations of bedbugs are sometimes apparent by detecting the blood spots voided by the fed bugs onto mattresses, linens, and even the walls, and by a peculiar odor characteristic of dense bug populations. To add insult to injury, bedbugs occasionally hide in luggage and accompany travelers home and establish a new infestation there. Pyrethroid insecticidal treatments to the sleeping quarters, particularly to the bed frame and mattress, can diminish their populations and associated bites. Eradication of bedbugs, however, often requires protracted and costly treatments to the premises.

The cone-nosed (triatomine) bugs of tropical and subtropical Central and South America burden people with more than their bites. As with bedbugs, cone-nosed bugs conceal themselves during the day (often in thatched roofs) and seek blood from almost any available warm-blooded host at night. Some triatomine bugs serve as vectors for the agent of American trypanosomiasis (Chagas disease), passing the infectious forms in their feces while feeding painlessly. Adults are winged and fly when disturbed or to establish new infestations. In heavily infested homes, residents may suffer dozens of bites each night, with individual adult bugs drawing up to 4 g of blood per meal. Applications of insecticidal fogs and residues to roof and walls of domiciles can reduce the population of the bugs and disease risk. Travelers in endemic regions are wise to select accommodations with solid (not thatched) ceilings or roofs, and with smooth walls without crevices.

Certain soft (argasid) ticks occasionally bite travelers staying in rodent-infested rustic cabins in the western United States. *Ornithodoros hermsii* ticks readily attack people at night. The brief (15–45 minute) episodes of blood feeding are generally unrecognized. These ticks may survive for a decade, with only an occasional meal needed for survival each year. These soft ticks pose occasional risk as vectors of the tick-borne relapsing fever spirochete that has sickened several people and proved fatal in a few cases [13].

Unlike lice, most fleas are not very host specific. Diverse fleas of rodents abound in and near the nests of their hosts, and readily bite people and their usual rodent hosts. In parts of the western United States and elsewhere in the world [14], rodents harbor the agent of plague. Backcountry trekkers to endemic areas should avoid camping near rodent burrows, and they may benefit from the use of insect repellents. In addition to plague, some rodent fleas can transmit murine typhus. Cat and dog fleas (*Ctenocephalides felis* and *C canis*, respectively) also readily bite people. *C felis* transmits *Bartonella henselae* to cats, and possibly to people. Eliminating cat and dog fleas depends on treating the animal hosts and premises, not the transient human host.

Parasites of momentary duration

Travelers are most aware of those arthropods that mount momentary attacks, such as mosquitoes, black flies, and tsetse flies. Less appreciated are the stealthy sand flies that pose risk of transmitting leishmaniasis. The habits, host preferences, and local abundance of each of these flies are functions of the region, season, and species composition. In general, protection from their bites outdoors is offered by covering exposed skin with clothing, and by use of insect repellents on skin and clothing. Clothing is most protective if it has a tight weave and is loose and baggy. Window screens, bed nets, and air conditioning can markedly reduce annoyance and risk from those biting insects that live or venture indoors. Although certain biting flies, such as the certatopogonids (“no-see-ums”) and psychodids (sand flies) are small enough to pass through the mesh of standard window screens and mosquito nets, they may be blocked with fine mesh screens or with ones that have been treated with insecticides.

Nonparasitic arthropods of medical significance

A broad array of arthropods may inflict damage simply in defensive mode, by accidental contact, or while foraging indiscriminately. Travelers virtually anywhere in North America or abroad may experience stings or bites from wasps, bees, ants, scorpions, spiders, and centipedes, but none of these serve as a vector. Similarly, urticating setae or blistering agents adorn some millipedes, beetles, and caterpillars. Travelers should exercise caution when handling arthropods unknown to them, reaching into dark recesses that might harbor a biting or stinging creature, or approaching nests of wasps and other social insects.

Pretrip and post-trip considerations

Just as travel-minded clinicians evaluate and offer their patients relevant pretravel vaccinations, prophylactic treatments, and guidance, so too should they consider and prepare the traveler to deal with arthropods and vector-borne illnesses they might encounter. Travel agents are rarely prepared to offer appropriate guidance [15]. Discussions should focus on the travelers’ destinations, choice of accommodations, and on the risks accompanying their planned activities (Table 1). Efficacious insect repellents should be packed or purchased at the destination and applied appropriately. Formulations based on DEET remain the best available repellents [16,17]. Clothing treatment with permethrin should be considered, and tick removal devices packed, for those likely to encounter ticks. Bed nets are commercially available; compactly packed; readily deployed; and can offer significant protection (especially if they are impregnated with insecticide) to travelers staying in endemic regions and where window screens or similar amenities may be absent.

Regardless of the precautions taken, certain unwanted guests, including bot flies, scabies mites, and lice, occasionally accompany the returning traveler home. Complaints of sensations elicited by these parasites may be suggestive of an active infestation or lingering reactions (sometimes for weeks afterward) of bites experienced while traveling. The clinician should

Table 1
Representative arthropods burdening travelers, and strategies to reduce risk of annoyance and disease

Ecologic group	Representative taxa	Geography	Manner of contact	Representative disease risks	Protection methods[a]
Chronic, perpetuating parasitism	Scabies mite (*Sarcoptes scabiei*)	Worldwide	Direct contact with infested person, bedding, or clothing	Pruritus, disseminated cutaneous infestation in immunocompromised hosts	A, H
	Human body louse (*Pediculus humanus*)	Worldwide	Direct contact with infested person, bedding, or clothing	Pruritus, systemic disease: louse-borne typhus, louse-borne relapsing fever, trench fever	A, D, E, H, I
	Human head louse (*Pediculus capitis*)	Worldwide	Direct head-to-head contact with infested person	Pruritus	G, H
	Human pubic louse (*Pthirus pubis*)	Worldwide	Direct (usually promiscuous) contact with infested person, bedding, or clothing	Pruritus	A, G, H
Extended stay for feeding or development	Chigoe flea (*Tunga penetrans*)	Tropics and subtropics	Exposed feet in infested areas	Local irritation, secondary bacterial infection	A, B, F, G
	Hard (Ixodid) ticks (eg, deer ticks (*Ixodes*); dog or wood ticks (*Dermacentor*); *Amblyomma*	Worldwide	Ticks quest for hosts in high grass and brush-covered sites	Lyme disease, human babesiosis, ehrlichiosis (anaplasmosis), tick-borne encephalitis (*Ixodes*); Rocky Mountain Spotted Fever, tick paralysis (*Dermacentor*); African tick-bite fever (*Amblyomma*)	A, B, C, D, F, G
	Myiasis-inducing fly larvae (eg, *Cordylobia anthropophaga, Dermatobia hominis, Gasterophilus intestinalis*)	Mainly tropics and subtropics	Adult female fly oviposits on body of host (*Gasterophilus*), on sweat or urine stained clothing (*Cordylobia*), or on a 'carrier' arthropod (*Dermatobia*),	Furuncular, wound, creeping dermal injury	B, C, D, E, G, I

Nest-inhabiting parasites	Bed bugs and relatives (*Cimex spp*)	Worldwide	Nocturnal feeding, mainly near beds	Pruritus	A, E, F
	Kissing or cone-nose bugs (Triatomines)	Tropical and subtropical Americas	Nocturnal feeding; bugs hide in thatched roofs and cracked mud walls	Chagas disease (American trypanosomiasis)	A, D, E, F
	Soft (Argasid) ticks; diverse hematophagous mites	Worldwide	Proximity to nests and dens of mammals, birds, reptiles	Tick-borne relapsing fever (certain soft ticks); rickettsialpox and pruritus (certain hematophagous mites)	A, C, D, F
	Fleas (eg, cat fleas, dog fleas, fleas of rodents)	Worldwide	Proximity to infested dogs, cats, rodents, and residences and yards where they may have roamed within past several months	Pruritus, often around ankles; plague (rodent fleas in endemic areas)	A, C, D, F
Ephemeral visitors (brief contact and feeding)	Mosquitoes (eg, *Anopheles, Aedes, Culex*)	Worldwide	Depending on kind of mosquito, females seek hosts outdoors or inside shelters; some feed mainly at night, others during the day, or mainly around dawn and dusk	Malaria, arboviruses, filariases	A, B, C, D, E
	Black flies (*Simulium*)	Worldwide	Diurnal, outdoor feeding, mainly near rivers and streams	Onchocerciasis	A, B, C, D
	Sand flies (eg, *Lutzomyia, Phlebotomus*)	Tropics and subtropics	Mainly nocturnal	Leishmaniasis	A, B, C, D, E, F

[a] Protection methods: A, Avoidance; B, Clothing barrier (long pants, long sleeves, socks, closed-toe shoes; baggy fabric or densely woven); C, Application of insect or tick repellents to body, clothing (DEET-containing repellents are most effective); D, Insecticide-impregnated clothing; E, Insecticide-treated nets (bed nets, screening); F, Area insecticide applications; G, Mechanical removal of parasite; H, Treatment of patient with appropriate antiparasitic agent; and I, Heat treating clothing.

make reasonable efforts to evaluate these cases fully, carefully considering the patient's destination and the activities he or she engaged in while away. Earnest attempts should be made to demonstrate an etiologic agent, and to submit any questionable specimen to an expert for evaluation. If neither the agent is discovered nor relief is offered by symptomatic or presumptive treatments, delusional parasitosis should be considered. Travelers who made use of accommodations infested with ticks, mites, bedbugs, or other vermin are advised to unpack and inspect their luggage and belongings carefully, and to launder their clothing immediately on their return. These steps may preempt the establishment of a new infestation.

Summary

Guidance has been offered to clinicians so they might better educate and advise travelers how to protect themselves, and evaluate complaints by travelers once they have returned. Any biting arthropod may cause direct injury, and the bite of just one infectious vector can be enough to prove fatal to the unprotected. Travelers and travel medicine practitioners should familiarize themselves with the vectors and vector-borne agents likely to be encountered corresponding to the traveler's specific itinerary, accommodations, and planned activities, and devise a rational strategy to reduce risk.

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