Ticks: human health and tick bite prevention

Tick avoidance and the use of appropriate methods of tick removal reduce the potential health-related impacts of tick bites.

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There are about 75 species of ticks in Australia, yet only a few bite humans. Among these, one particular species dominates in terms of its ill effects: the Paralysis tick, *Ixodes holocyclus* (Figures 1a and b). The bite from this tick can occasionally result in severe allergic reactions or the transmission of infectious agents, and rarely in life threatening paralysis. Despite being a commonly encountered pest, knowledge about this tick is often grossly inaccurate and widely held misconceptions have almost made it into Australian folklore.

This article attempts to provide accurate information on the Paralysis tick, with details on potential clinical effects and notes on patient management. The lifecycle and ecology are discussed as knowledge of these is essential for reducing contact with the species. Other ticks that bite humans, and their impact on health, are briefly reviewed.

What is a tick?

Ticks belong to the animal class Arachnida, which also includes spiders and mites. All ticks are external parasites requiring blood for development and, in the case of the adult female tick, for egg production. During blood feeding, ticks inject saliva containing an anticoagulant as well as various other components that may cause allergic reactions and/or paralysis. The Paralysis tick belongs to a group known as the 'hard' ticks, which are flattened when unfed and swell up into a ball during blood feeding. All stages of the Paralysis tick are ovoid in shape. The ticks have a deep brown colouration that during feeding becomes almost black in the juvenile stages and grey in adult females (adult males tend not to blood feed on a host).

It is advisable to confirm the identity of any suspect tick with appropriate experts, although there are very few laboratories in Australia that have experience in tick identification. The Department of Medical Entomology at Westmead Hospital is NATA (National Association of Testing Authorities) accredited for the identification of arthropods of medical importance and can provide this service.

Lifecycle and ecology

The Paralysis tick occurs along the eastern coast of Australia, from north Queensland to Melbourne.

IN SUMMARY

- **The Paralysis tick is the most commonly encountered tick attaching to humans in Australia, and occurs along the east coast.**
- **Bites from the larvae are especially frequent, particularly during mid- to late summer and early autumn (February to May).**
- **Possible adverse effects from the bite include allergic reactions (even anaphylaxis), paralysis and tick typhus rickettsiae.**
- **Antitoxin is available for patients suffering from tick paralysis.**
- **Prevention of tick bite includes habitat avoidance and the use of insect repellents.**
- **Other tick species that occasionally bite humans include the Kangaroo tick and the Brown Dog tick.**

Figures 1a and b. Paralysis tick, *Ixodes holocyclus*. a (left). Adult female, roughly 3 to 3.5 mm in length. b (right). Adult male, roughly 2.5 to 3.0 mm in length.

The species is most abundant in moist native forests, where its main hosts, bandicoots, live.

There four stages in the lifecycle: eggs, larvae (sometimes called grass or seed ticks), nymphs and adults (bush, scrub, shellback or Paralysis ticks). The stages tend to be seasonal, with larvae more abundant during mid- to late summer and autumn, nymphs during late autumn and winter, and adults in spring and early summer (Figure 2). The complete life cycle (involving the four stages and three blood feeds) takes about a year to complete.

Adult female ticks can each lay up to 2500 eggs (Figure 3). The tiny six-legged larvae that emerge search for a host by climbing the nearest vegetation and waiting until a warm-blooded animal brushes past. Contrary to popular belief, ticks of any stage rarely climb higher than about 50 cm, for risk of desiccation, and do not drop out of trees; however, they can wander over the host for some hours before attaching, often ending up on the head. Larvae tend not to move far in the vegetation from where they hatch and, therefore, many can be present in a small area. This is why multiple larval bites, numbering in the tens to even hundreds, are common. Unfed larvae are roughly 0.5 mm in length, and enlarge to about 1.5 mm after four to six days of blood feeding. There is a high level of mortality between this and the next stage, with the result that encounters with larvae are more likely than with any other stage. At the end of feeding, the larvae drop off the host randomly and moult into the eight-legged nymphal stage (Figure 4). The 1.0 to 1.5 mm nymphs require a further blood feed for five to seven days before moulting to the adult stage.

The adult females and males show marked differences in appearance and behaviour (see Figures 1a and b). Adult females, which are 3.0 to 3.5 mm in length, blood feed for about eight days (up to 21 days in midwinter) before dropping off to lay eggs, wither and die. Male ticks, which are slightly smaller than females (2.5 to 3 mm in length), tend not to blood feed on a host but search the host for female ticks in order to mate and feed from them (parasitising them). Thus they are of little medical concern.

The Paralysis tick and health

Allergic responses

Local reactions

The most common clinical association with ticks is a local allergic reaction from the bite, with the formation of a papule.

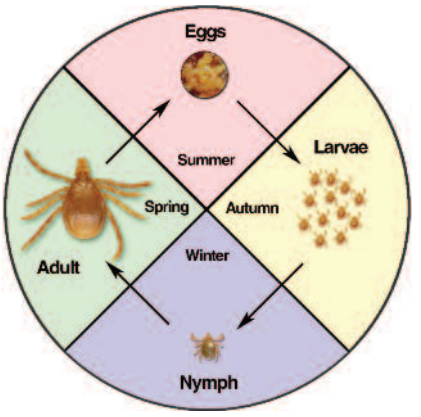

Figure 2. Life cycle of the Paralysis tick. The various stages tend to be seasonal, with some overlap in generations.

Figure 3. A fully engorged female Paralysis tick laying eggs. One female tick can produce up to 2500 eggs, with each one potentially hatching out to the larval stage.

Figure 4. A semi-engorged nymphal Paralysis tick.

Sometimes the swelling can be intense locally, giving the appearance that tick has burrowed into the skin, whereas only the mouthparts are actually inserted (Figure 5). After removal of the tick, the bite site can remain inflamed and itchy for many weeks (Figure 6). Forcibly removing the tick using tweezers or scratching it out, either intentionally or unintentionally, can leave some of the mouthparts behind (Figure 7), and a granuloma may form at the bite site. However, complications from the retained mouthparts are rare as they soon fall out with the natural sloughing of the skin; surgical excision is rarely needed.

Multiple larval tick bites are common during the early months of the year, especially on the lower limbs and around the waist, and often referred to as 'scrub-itch' (Figure 8).[1]

Figure 5 (above). Localised swelling is obscuring the head and front legs of this adult female Paralysis tick that is embedded in the scalp.

Figure 6 (right). A severe local allergic reaction associated with a nymphal tick bite on the inner arm.

Anaphylactic reactions

Individuals can become sensitised to Paralysis tick bites. Symptoms can develop quickly after a bite from a larval, nymphal or adult tick, especially following tick removal, and may include intense swelling with pain and a potentially fatal anaphylactic reaction. In a recent report, it was concluded that tick bite anaphylaxis is more common and potentially life threatening than tick paralysis.[2] This is supported by the considerable number of inquiries our Department receives from distressed parents seeking advice on how to reduce the possible exposure to ticks of their children who suffer severe allergic reactions following a tick bite.

Tick avoidance is imperative for those patients who suffer severe reactions to tick bites. This may mean moving to a more urbanised location if currently residing near bushland where ticks are common. If high risk areas are unavoidable, adrenaline (Adrenaline 1:1000, Adrenaline Hydrochloride 1:1000; EpiPen, EpiPen Jr) needs to be readily available and attached ticks must be treated as recommended below. Immunotherapy used to be an option, but tick antigen is no longer commercially produced for desensitisation treatments.

Paralysis

The clinical entity that gives *I. holocyclus* its common name has been known for a long time, with early reports of paralysis by the explorers Hume and Hovell during the 1820s, and the first recorded death in 1904. There have been 20 documented fatalities from tick paralysis, and about 70% of these have been children under 4 years of age.[3] In all cases when known, the tick attachment site was on the chest or higher, and the vast majority were on the head region. Sometimes ticks attach in body orifices such as the ear canal, making a definitive diagnosis difficult. Improvements in medicine and the availability of tick antitoxin have led to no deaths being reported since 1945. However, occasional cases of tick paralysis do still occur, mainly in children. These rare cases are often unrecognised or misdiagnosed. For example, in a recent case at Westmead Hospital, the cause of a mysterious coma in a young patient was found serendipitously when a nurse, through an act of tenderness, discovered the tick while stroking the child's head.

The adult female tick is responsible for causing the paralysis, with symptoms beginning about three to four days after attachment.[4,5] Typically, the syndrome involves an ascending flaccid paralysis, beginning with unsteadiness while walking and a generalised lethargy. Sensory impairment is not often reported. Over 24 hours, the paralysis will continue to involve the arms and the muscles involved with swallowing and breathing, with the patient possibly requiring artificial ventilation. Deaths in the past have been due to respiratory failure. The eye muscles are often affected and patients can have trouble reading. Symptoms often deteriorate within 48 hours of the tick being removed and observation of the patient during this period is critical. A full recovery is usually slow and may take several weeks.

Tick antitoxin (marketed as Tick Antivenom) is available from the Commonwealth Serum Laboratories and consists of hyperimmune dog sera. The antitoxin is readily available but rarely administered, only two patients having received it between late 1994 and mid-2002 (personal communication, Associate Professor Julian White, Adelaide). Although no serious allergic reactions to the sera have been

reported, side effects are known, and it is usually advised that the antitoxin be administered only to patients with significant paralysis. Further information on the antitoxin and its use is available from the online version of the *Australian CSL Antivenom Handbook*.[6]

Infectious diseases

Of all the blood sucking arthropods worldwide, ticks transmit the greatest range of pathogens, including bacteria, protozoans, rickettsiae and viruses. Fortunately, Australia has very few tick-borne diseases, cases are relatively rare and few fatalities have been recorded.

Spotted fevers

The main pathogens of concern in Australia are the spotted fever rickettsiae, including Queensland tick typhus (caused by *Rickettsia australis*) and Flinders Island spotted fever (*R. honei*).[7] As the latter has only been recently described, the distributions of the two diseases have not been fully delineated. It appears that Queensland tick typhus occurs from north Queensland down to southern New South Wales and Flinders Island spotted fever from southern New South Wales to Victoria and Tasmania.

Despite this lack of distinction in distribution, the two diseases are clinically similar and treatment is identical. Typically, onset of disease is abrupt and begins with fevers, malaise, headache, myalgia, local skin lesions and tender lymphadenopathy. An eschar at the bite site occurs in many cases. Most patients develop a skin rash within one to 12 days after symptoms appear. This rash varies in presentation: usually it will be macular or maculopapular, occasionally becoming petechial, and it can be generalised or sparse, and sometimes vesicular. Various other symptoms are often reported, and serology is often required to confirm the diagnosis by demonstrating rising titres between the acute and convalescent sera. Treatment is with antibiotics, notably doxycycline, with the daily dose for adults being 100 mg orally 12-hourly for seven to 10 days.[8]

The Paralysis tick appears to be the main vector for the spotted fever rickettsiae in most of eastern Australia but other tick species are involved in the southern areas of the country (see below under 'Other tick species').

Is there Lyme disease in Australia?

There were reports of cases of Lyme disease from the Hunter region of New South Wales in the mid-1980s, at a time when the disease was being recognised in many countries in the Northern Hemisphere. An extensive survey of pathogens in ticks undertaken by our laboratory during the early 1990s did not find any evidence of *Borrelia burgdorferia*, the causative agent of true Lyme disease, or any other spirochaete.[9] Other research has indicated that the Paralysis tick is unable to transmit a US strain of *B. burgdorferia*. Overall, there is little to no scientific evidence to support the existence of Lyme disease in Australia.

There have been isolations of the Lyme disease bacterium from Australian patients, but all these patients have had a travel history to endemic regions of the Northern Hemisphere. Overseas travellers should take the appropriate precautions to avoid tick bite when in areas where Lyme disease is endemic.

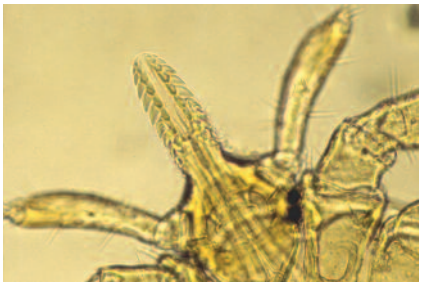

Figure 7 (above). The mouthparts of ticks are barbed and if forcibly removed usually break off.

Figure 8 (right). Multiple bites from larval Paralysis ticks. Over 20 larval ticks were removed from this patient.

Removal of attached ticks

If poetic licence has been granted to one aspect of tick folklore, it is surely that of removal, with suggested methods including painting the tick with nail varnish, Vaseline, turps or sodium bicarbonate, using heated matches, and removal via loops of cotton. Our Department has even received for identification ticks that have been excised surgically, several that have been removed via punch biopsies and others that have been sectioned, mistakenly as skin lesions. However, most of the above removal methods are based on tradition and not science.

Recently, there has been debate on the best way to remove ticks, and two methods have been proposed.

Rapid removal with forceps

The first method is the more traditional approach, in which ticks are removed as soon as possible after discovery with the aid of fine tipped forceps by grasping the tick close to the skin and pulling it out firmly.

The Stone method

Dr Bernard Stone, formerly of the CSIRO (now retired) and Australia's leading

researcher on the toxin of the Paralysis tick, developed another method. Dr Stone reported that an anaphylactic reaction is more likely to occur soon after a tick is removed than if it is left in place, leading to deterioration of the condition of a patient suffering paralysis. To reduce this happening, Dr Stone proposed the following method of tick removal:[10]

- **Avoid touching, manipulating or initially removing the tick**. Any movement of the tick can stimulate the release of more of its toxic saliva. Also, during feeding the toxins accumulate at the bite site and forced removal of the tick results in a rapid dispersal of these toxins, leading to a worsening of symptoms.
- **Spray the tick with an aerosol repellent containing a synthetic pyrethroid**. The hydrocarbon propellent acts as a narcotic agent, while the synthetic pyrethroid acts as a toxicant. The combination rapidly kills the tick *in situ* and prevents further toxin being injected. However, repellents containing synthetic pyrethroids are not readily available. An alternative is to use a permethrin based scabies cream such as Lyclear or Quellada Scabies Treatment, which can be dabbed directly onto the tick.
- **Treat the tick again with aerosol repellent one minute later**.
- **Leave the tick for several hours without removing**. Once dead, the tick will shrivel up and darken, and may fall off naturally. If it remains attached, it can be removed with fine tipped forceps. The bite site can then be disinfected to prevent any secondary infections, which are uncommon.

Recommended method

In a meeting in early 2004 chaired by NSW Health and involving various stakeholders (unpublished to date), the method involving rapid removal using tweezers was the procedure recommended by the NSW State Health System. (Most other States and Territories do not have recommended procedures, although many hospitals in Queensland follow the Stone method.)

It is important to note, however, that neither the rapid removal method nor the Stone method has undergone clinical trials and thus it not known which is best at reducing possible clinical sequelae. As an adjunct, many patients who have used both methods have reported anecdotally to the author that they prefer the Stone method because symptoms following tick removal are not as intense or prolonged.

No matter which method is used, the patient should be advised that if any symptoms develop after the tick is removed, medical assistance should be sought. If a patient is known to suffer severe allergic or anaphylactic reactions or potentially may do so, the tick should only be removed in a clinical setting containing life support equipment.

Prevention of tick bites

The best form of tick prevention is avoidance, and knowledge of the tick's ecology is essential to achieve this. As previously mentioned, the preferred habitats are moist native forests close to the coast. Host searching behaviour by ticks peaks during humid periods, and tick attack is especially common after rain.

To reduce the risk of tick bite while in a known infested area, light coloured, fully covering garments should be worn (the light colour helps in the spotting of ticks) and self-inspection regularly performed. Shirts should be tucked into trousers and trousers into socks, and clothing should be removed as soon as possible and placed in a hot clothes dryer for 20 minutes to kill any ticks. Tick bites often occur in areas of the body that are covered by clothes. Insect repellents containing N,N-diethyl-M-toluamide (DEET), such as Rid, Mortein Aerogard, Bushman, Johnson Off, Pea Beu Bite Free, or picaridin, such as Autan Repel, should be applied, especially to the lower part of the body, using creams on the skin and sprays to

Figure 9. A nymphal Paralysis tick embedded behind the ear. This tick has been in place for less that two hours and is yet to swell up with blood. Behind the ears is a common place for ticks to attach, especially in children.

clothing and footwear. Herbal repellents made from citronella, tea tree (melaleuca) or eucalyptus oil are not considered particularly effective at repelling ticks.

Self-inspection by adults and children, and inspection of young children by adults, involves a thorough search for ticks over the whole body. In children, special attention should be paid to the head region, particularly behind the ears (Figure 9), because hair can hide the tick.

Other tick species that bite humans

Occasionally ticks other than the Paralysis tick will bite humans and impinge upon human health.

Kangaroo tick

Amblyomma triguttatum, the Kangaroo tick, comprises a complex of closely related species found throughout the drier regions of Australia. Bites to humans are not uncommon and localised skin reactions often occur. The tick is not known to spread any disease agents to humans.

Aponomma hydrosauri

Aponomma hydrosauri is associated with reptiles, such as blue tongue lizards, goannas, shingle back lizards, long necked tortoises, bearded dragons and tiger snakes. It transmits the agent of Flinders Island

spotted fever, *R. honei*. This tick is found in Tasmania, Victoria and some southern parts of South Australia and New South Wales.

Ixodes cornuatus

Ixodes cornuatus has been reported as causing tick paralysis in humans. However, the taxonomy of the group to which it belongs is not well defined and reports may represent misidentifications of the closely related Paralysis tick.

Ornithodoros capensis

Ornithodoros capensis, a tick that occurs commonly on the offshore islands of the Barrier Reef in association with nesting birds, occasionally bites humans. Allergic reactions to the bite are common. Several viruses have been isolated from this tick, but humans do not appear to be adversely affected.

Brown Dog tick

Rhipicephalus sanguineus, the Brown Dog tick, is an introduced species that occurs throughout Australia but more commonly in drier regions. Although it occasionally bites humans and has been incriminated in the transmission of Q fever, it is not thought to be a major health threat.

Conclusion

Unpopular as it may be, the Paralysis tick is native to Australia and part of a healthy ecosystem. Unfortunately, there has been a marked upsurge in tick populations in recent years, and a corresponding increase in tick-related incidents with patients. Proper advice on tick avoidance and the use of appropriate methods of tick removal should reduce potential health related impacts. MT

Further information

The Westmead Hospital Department of Medical Entomology website (www. medent.usyd.edu.au) has fact sheets on ticks and tick-borne diseases as well as many images relating to ticks.

Acknowledgements

Associate Professor Julian White (Director, Toxinology Department, Women's and Children's Hospital, Adelaide, and Consultant Clinical Toxinologist to CSL Ltd and Australian PIC Network) provided the information on the frequency of use of CSL tick antivenom. Associate Professor Richard Russell (Department of Medical Entomology, University of Sydney and ICPMR, Westmead Hospital) critically reviewed the manuscript.

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DECLARATION OF INTEREST: None.