Bluetongue viruses, vectors and surveillance in Australia – the current situation and unique features

P.D. Kirkland

Virology Laboratory, Elizabeth Macarthur Agricultural Institute, PMB 8, Camden, NSW 2570, Australia

Summary

While there are dramatic differences between recent bluetongue (BT) developments in Europe and the situation in Australia, there are also a number of similarities. About 25 years ago, as a BT-free country, Australia was advised that a BT virus (BTV) had been identified, though there was no evidence of disease. During the following 15 years, 8 BTV serotypes were identified. Despite the presence of some virulent viruses, Australia remains free of BT disease. Nevertheless, the economic impact is considerable due to disruption to trade. In the last decade, research efforts have focussed on reducing the impact of BTVs on the export of livestock, semen and embryos. In 1993, the National Arbovirus Monitoring Program (NAMP) was established as a co-operative initiative between the livestock industries, national and state governments. The main emphasis of NAMP has been to define the distribution of BTVs and their vectors, together with monitoring annual fluctuations of viruses and vectors. A combination of climatic, geographical, virus and vector monitoring data that have been gathered over more than 25 years, have allowed the accurate delineation of BTV-free zones and zones of possible BTV transmission in accordance with OIE guidelines. These zones are now promoted to trading partners to facilitate trade.

Keywords

Australia – Bluetongue-free zones – Bluetongue viruses – *Culicoides* – Epidemiology – Surveillance – National Arbovirus Monitoring Program.

While there are dramatic contrasts between the bluetongue (BT) situation in Europe and Australia, there are also similarities. Some European countries, previously free of BT, have recently experienced either significant outbreaks of disease in sheep, or the discovery of the presence of BT viruses (BTVs). About 25 years ago, Australia faced a similar situation.

In 1977, Australian animal health authorities were advised that a virus that had been isolated two years previously from insects had just been identified as a BTV (25). This was the first recognition of BTV serotype 20. As a country with a population of more than 140 million sheep, Australia had exotic disease plans to respond to an incursion of a BTV. Consequently, the livestock industries struggled with this news when there was no evidence of disease but the presence of a virus that halted exports of animals and, in some cases, even animal products.

Over the next decade, the distribution of BTVs was investigated. Initially, serogroup reactive tests were employed to determine the maximum possible distribution of BTVs. Positive samples were then tested in serotype-specific virus neutralisation (VN) tests. Results of VN tests suggested that the original BTV isolate of serotype 20 was not widely distributed but certain other serotypes, especially serotype 1, may be present (11). In some instances, type-specific results for sera that had given strong serogroup test reactivity were negative. This suggested that there may be additional, as yet unrecognised, serotypes present. Virus isolation studies on blood samples collected from sentinel cattle yielded a number of isolates of BTV-1 and also another new serotype, BTV-21 (27). Epidemiological studies conducted in several states defined the limits of BTVs in Australia (9, 13, 20, 28). Intensive investigations continued at the Coastal Plains site in far Northern Australia, where the first BTV had

been identified. Over a period of four years, another five serotypes of BTV, namely BTV-3, BTV-9, BTV-15, BTV-16 and a further new serotype, BTV-23, were isolated (14, 15, 16). No new serotype of BTV has been isolated in Australia since 1986.

Experimental studies of the virulence of BTVs in sheep have shown that there is a spectrum, ranging from apparently non-pathogenic to moderately virulent (12, 17, 18, 19, 26, 29). Among the pathogenic isolates, Australian viruses appear to be considerably less virulent than South African strains (17). Under natural conditions, disease has not been recorded in commercial sheep flocks. This is due to a combination of factors – sheep are rarely raised in areas where BTVs are transmitted, the incidence of infection of sheep in these areas is low and the viruses that are present in regions in proximity to major sheep populations are considered to be non-virulent. Two disease incidents have been observed when small groups of sheep have been moved into the tropical north of the Northern Territory. Clinical signs were observed in six animals from the two incidents. Disease associated with BTV infection has never been observed in commercial sheep flocks, cattle or goats in Australia.

Entomological research has shown that there are five species of *Culicoides* in Australia that are potentially capable of transmitting BTVs, namely *C. actoni*, *C. brevitarsis*, *C. fulvus, C. brevipalpis* and *C. wadai* (1, 23, 24, 30, 31, 32); *C. brevitarsis* is considered to be the major BTV vector in Australia and is the most widely distributed. The other midge species have a less expansive distribution and are all confined to areas that lie within the range of *C. brevitarsis*. Data obtained from intensive studies of the ecology of *C. brevitarsis* has allowed a detailed understanding of the factors that affect the survival, multiplication and dispersal of this principal BTV vector (2, 3, 4, 5, 6, 7). These data have been utilised to develop models that predict the rates of movement and survival of *C. brevitarsis* (3, 8).

In the last decade, surveillance and research efforts have focussed on reducing the impact of BTVs on the export of livestock, semen and embryos. In 1993, a co-ordinated Australia-wide surveillance and monitoring programme, the National Arbovirus Monitoring Program (NAMP), was formally established as a co-operative initiative between the livestock industries, national and state governments. Funding of the programme is shared between these groups. This programme has operated continuously in Australia since its establishment in 1993. The main emphasis of NAMP has been on the definition of the distribution of BTVs and their vectors, together with monitoring annual fluctuations of viruses and vectors. These objectives have been largely achieved by the sampling of sentinel cattle at key locations around Australia and by light-trap collection of insects at these sentinel sites. Groups of 10-20 young cattle are sampled at sentinel herd locations. Animals are preferably less than 12 months old and free of maternal antibodies at the time of first sampling. In areas where BTV transmission may occur, animals are sampled at monthly intervals from summer through to the start of winter. At the tropical Coastal Plains site in the Northern Territory where the first isolate of BTV was obtained, animals are sampled at weekly intervals for 5-7 months each year. In other areas, sampling is less frequent, depending on the likelihood of BTV infection occurring. In proven free regions, animals may only be sampled at the commencement of summer and at the end of the vector season. Periodically, structured serological surveys are used to complement the sampling of sentinel animals. Data obtained from these surveys is used to refine the location of sentinel sites.

Serum samples from sentinel cattle are first tested for serogroup reactive antibodies by competitive ELISA (c-ELISA). Positive sera are tested for serotype-specific antibodies using the VN test. Blood cells are retained for future virus isolation attempts if an animal seroconverts. BTVs that are isolated are subjected to genetic analyses (topotyping) to identify the geographical origin of the viruses. While there have been no new serotypes of BTV found in Australia since 1986, the results of genetic analyses would suggest that there is an intermittent introduction of new strains of BTV into Australia from time to time (21, 22). Results of the NAMP have shown that only two serotypes (1 and 21) are widely distributed through northern Australia and along the eastern coast as far south as central New South Wales. The other six serotypes, including the viruses known to be virulent, remain confined to a small area in the far north of the Northern Territory and northern part of Western Australia.

A network of insect collection sites is spread throughout the areas of possible BTV transmission and in the adjoining BTV-free areas. Biting midges (*Culicoides* species) are collected in light traps that are operated for varying periods depending on the local climate and the likelihood of vector activity. Insect collections are sorted to species and quantified.

Data collected from sentinel cattle monitoring and insect collections are submitted to a central database through an internet-based data management system called 'NAMP Info' (10). This database holds details of all monitoring sites as well as summaries of all virology and entomology results. The data are used to generate annual maps of BTV distribution

throughout Australia and subsequently maps of BTV-free zones, zones of possible BTV transmission, and surveillance zones in accordance with OIE guidelines. There is unrestricted access to the current BTV zone map through the NAMP website (www.namp.com.au). These maps are available in a range of downloadable electronic formats as well as an online interactive format.

The NAMP is reviewed at an annual meeting of representatives from the cattle, sheep and livestock export industries, national government and state governments through key scientists (entomologists, epidemiologists and virologists). At the annual review meeting, monitoring results are reviewed and the location of monitoring sites and frequency of monitoring are adjusted to take into account any variations of virus and vector distribution during the previous year.

In addition to supporting the activities of the NAMP, Australian scientists continue to be engaged on a range of BT-related research projects. Current projects are directed towards detailed studies of vector ecology, modelling of virus and vector distribution, vector reduction strategies, improved vector collection techniques and refinements to diagnostic procedures.

In order to minimise the disruption to trade and to manage the risks associated with the presence of BTVs, Australia has established a BTV-free zone and a zone of possible transmission. When the entomology and virology data are collated and integrated with national geographical data, there is a strong foundation for the definition of the limits of BTVs in Australia. Australia has a number of unique features that contrast with other countries and continents. It is a large, geologically stable and ancient landmass. The landform is relatively uniform, flat and continuous. Consequently, there is a continuous distribution of vectors and viruses across northern and eastern Australia, progressing towards a southerly limit imposed by the climate. There are no major mountains to disrupt the north-south movement of viruses and vectors. Similarly there is a continuous distribution of livestock, with populations of cattle in the northern and eastern regions of higher rainfall and temperature and very large flocks of sheep in the cooler drier areas. Collectively, these factors, when combined with virus and vector monitoring data that have been gathered for over more than 25 years, have allowed the delineation of BTV-free zones and zones of possible BTV transmission in accordance with OIE guidelines. These zones are now being promoted to trading partners to assist the export of live ruminants. A number of papers and posters presented during this symposium will provide more detailed information on aspects of recent BTV research and management in Australia.

References

1. Bellis G.A., Gibson D.S., Polkinghorne I.G., Johnson S.J. & Flanagan M. (1994). – Infection of *Culicoides brevitarsis* and *C. wadai* (Diptera: Ceratopogonidae) with four Australian serotypes of bluetongue virus. *J. Med. Entomol.*, **31** (3), 382-387.
2. Bishop A.L. & McKenzie H.J. (1994). – Overwintering of *Culicoides* spp. (Diptera: Ceratopogonidae) in the Hunter Valley, New South Wales. *J. Aust. Entomol. Soc.*, **33**, 159-163.
3. Bishop A.L. Barchia I.M. & Harris A.M. (1995). – Last occurrence and survival during winter of the arbovirus vector *Culicoides brevitarsis* at the southern limits of its distribution. *Aust. Vet. J.*, **72**, 53-55.
4. Bishop A.L., Kirkland P.D., McKenzie H.J., Spohr L.J., Barchia I.M. & Muller M.J. (1995). – Distribution and seasonal movement of *Culicoides brevitarsis* Kieffer (Diptera: Ceratopogonidae) at the southern limits of its distribution in New South Wales and their correlation with arboviruses affecting livestock. *J. Aust. Entomol. Soc.*, **34**, 289-298.
5. Bishop A.L., Kirkland P.D., McKenzie H.J. & Barchia I.M. (1996). – The dispersal of *Culicoides brevitarsis* in eastern New South Wales and associations with arbovirus infections in cattle. *Aust. Vet. J.*, **73,** 174-179.
6. Bishop A.L., McKenzie H.J., Barchia I.M. & Harris A.M. (1996). – Effect of temperature regimes on the development, survival and emergence of *Culicoides brevitarsis* Kieffer (Diptera: Ceratopogonidae) in bovine dung. *Aust. J. Entomol.*, **35**, 361-368.
7. Bishop A.L., McKenzie H.J., Barchia I.M. & Harris A.M. (1998). – Occurrence and effect of temperature regimes on four species of fly (Diptera) found with *Culicoides brevitarsis* Kieffer (Diptera: Ceratopogonidae) in bovine dung. *Gen. Appl. Entomol.*, **28**, 93-99.
8. Bishop A. L, Barchia I.M. & Spohr L.J. (2000). – Models for the dispersal in Australia of the arbovirus vector *Culicoides brevitarsis* Kieffer (Diptera: Ceratopogonidae). *Prev. Vet. Med.*, **47**, 243-254.
9. Burton R.W. & Littlejohns I.R. (1988). – The occurrence of antibody to bluetongue virus in New South Wales. I: Statewide surveys of cattle and sheep. *Aust. J. Biol. Sci.*, **41**, 563-570.
10. Cameron A.R. (2000). – Development of an internet-based information system for monitoring veterinary arboviruses and their vectors. *In* Proc IXth Symposium of the International Society of Veterinary Epidemiology Economics (ISVEE), Breckenridge, August.
11. Della-Porta A.J., Sellers R.F., Herniman K.A.J., Littlejohns I.R., Cybinski D.H., St George T.D., McPhee D.A., Snowdon W.A., Campbell J.,

Cargill C., Corbould A., Chung Y.S. & Smith V.W. (1983). – Serological studies of Australian and Papua New Guinean cattle and Australian sheep for the presence of antibodies against bluetongue group viruses. *Vet. Microbiol.*, **8**, 147-162.

12. Forman A.J., Hooper P.T. & Le Blanc Smith P.M. (1989). – Pathogenicity for sheep of recent Australian bluetongue virus isolates. *Aust. Vet. J.*, **66**, 261-262.
13. Gard G.P., Shorthose J.E., Cybinski D.H. & St George T.D. (1985). – Epidemiology of orbiviruses in the Northern Territory of Australia. *In* Veterinary viral diseases: their significance in South-East Asia and the Western Pacific (A.J. Della-Porta, ed.). Academic Press, Sydney, 423-425.
14. Gard G.P., Shorthose J.E., Cybinski D.H. & Zakrzewski H. (1985). – The isolation from cattle of 2 bluetongue viruses new to Australia. *Aust. Vet. J.*, **62**, 203.
15. Gard G.P., Shorthose J.E., Weir R.P. & Erasmus B.J. (1987). – The isolation of a bluetongue serotype new to Australia. *Aust. Vet. J.*, **64**, 87-88.
16. Gard G.P., Weir R.P., Melville L.F. & Lunt R.A. (1988). – The isolation of bluetongue types 3 and 16 from northern Australia. *Aust. Vet. J.*, **64**, 388.
17. Hooper P.T., Lunt R.A. & Stanislawek W.L. (1996). – A trial comparing the virulence of some South African and Australian bluetongue viruses. *Aust. Vet. J.*, **73** (1), 36-37.
18. Johnson S.J., Hoffman D., Flanagan M., Polkinghorne I.G. & Bellis G.A. (1990). – Pathology, signs and symptoms of bluetongue in Australia. *Aust. Adv. Vet. Sci.*, **22**, 24.
19. Johnson S.J., Hoffman D., Flanagan M., Polkinghorne I.G. & Bellis G.A. (1992). – Clinico-pathology of Australian bluetongue viruses for sheep *In* Bluetongue, African horse sickness and related orbiviruses (T.E. Walton & B.I. Osburn, eds). Proc. Second International Symposium, Paris, 17-21 June 1991. CRC Press, Boca Raton, 737-743.
20. Littlejohns I.R. & Burton R.W. (1988). – The occurrence of antibody to bluetongue virus in New South Wales. II: Coastal region and age distribution surveys. *Aust. J. Biol. Sci.*, **41**, 571-578.
21. McColl K.A., Gould A.R., Pritchard L.I., Melville L. & Bellis G. (1994). – Phylogenetic characterisation of bluetongue viruses from naturally-infected insects, cattle and sheep in Australia. *Aust. Vet. J.*, **71**, 102-105.
22. Melville L.F., Pritchard L.I., Hunt N.T., Daniels P.W. & Eaton B. (1997). – Genotypic evidence of incursions of new strains of bluetongue viruses in the Northern Territory. *In* Proc. 7th Symposium on arbovirus research (B.H. Kay, ed). QIMR, Brisbane, 181-189.
23. Muller M.J. (1985). – Experimental infection of *Culicoides brevitarsis* from south-east Queensland with three serotypes of bluetongue virus. *Aust. J. Biol. Sci.*, **38**, 73-77.
24. Muller M.J. (1987). – Transmission and *in vitro* excretion of bluetongue virus serotype 1 by inoculated *Culicoides brevitarsis* (Diptera: Ceratopogonidae). *J. Med. Entomol.*, **24**, 206-211.
25. St George T.D., Standfast H.A., Cybinski D.H., Dyce A.L., Muller M.J., Doherty R.L., Carley J.G., Filippich C. & Frazier C.L. (1978). – The isolation of a bluetongue virus from *Culicoides* collected in the Northern Territory of Australia. *Aust. Vet. J.*, **54**, 153-154.
26. St George T.D. & McCaughan C.J. (1979). – The transmission of the CSIRO 19 strain of bluetongue virus type 20 to sheep and cattle. *Aust. Vet. J.*, **55**, 198-199.
27. St George T.D., Cybinski D.H., Della-Porta A.J., McPhee D.A., Wark M.C. & Bainbridge M.H. (1980). – The isolation of two bluetongue viruses from healthy cattle in Australia. *Aust. Vet. J.*, **56**, 562-563.
28. St George T.D., Cybinski D.H. & Standfast H.A. (1982). – The continued search for bluetongue related viruses in Australia. *In* Arbovirus research in Australia (T.D. St George & B.H. Kay, eds). CSIRO/QIMR, Brisbane, 188-193.
29. Squire K.R.E., Uren M.F. & St George T.D. (1981). – The transmission of two new Australian serotypes of bluetongue virus to sheep. *Aust. Vet. J.*, **57**, 301.
30. Standfast H.A., St George T.D., Cybinski D.H., Dyce A.L. & McCaughan C.J. (1978). – Experimental infection of *Culicoides* with a bluetongue virus isolated in Australia. *Aust. Vet. J.*, **54**, 457-458.
31. Standfast H.A., Dyce A.L. & Muller M.J. (1985). – Vectors of bluetongue virus in Australia. *Progr. Clin. Biol. Res.*, **178**, 177-186.
32. Standfast H.A., Muller M.J. & Dyce A.L. (1992). – An overview of bluetongue virus vector biology and ecology in the Oriental and Australasian Regions of the Western Pacific. *In* Bluetongue, African horse sickness and related orbiviruses (T.E. Walton & B.I. Osburn, eds). Proc. Second International Symposium, Paris, 17-21 June 1991.CRC Press, Boca Raton, 253-261.