The epidemiology of bluetongue

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Summary: The survey methods used to map the world-wide distribution of bluetongue and its serotypes are outlined together with a consideration of the role of insect vectors in determining this distribution. Bluetongue is portrayed as a mobile virus moving within its endemic zone with the seasonal migration of insects. Finally, these aspects are considered from the viewpoint of trade in livestock and germ plasm.

KEYWORDS: Arbovirus - Bluetongue virus - Epidemiological surveys - Insects - International trade - Livestock - Season - Sheep diseases.

For a given pathogen the epidemiologist may be called on to provide insights into the distribution, the maintenance mechanisms and the various strategies it uses to exploit animal populations. This knowledge is obviously needed as the basis for logical systems of disease control leading to increased herd sizes and improvements in productivity, but given that these goals have been achieved, what then? Farmers may want to exchange genetic material either by trade in live animals or, to a growing extent, by the movement of semen and embryos. Equally they may wish to move livestock across national borders to compete for markets. One looks, then, at the task of facilitating the free movement of livestock or livestock products between countries that have reached equivalent levels of zoo-sanitary control — a concept very much in line with current European objectives. It is in this general area that epidemiologists are still making large contributions and I would like to think that the future of the AVRI will be linked with the facilitation of safe international livestock trade. Using bluetongue as my exemplar I would like to try to fill out these opening remarks.

Pirbright was first called upon to carry out investigations into bluetongue in response to questions raised in the British Parliament following the explosive outbreak of the disease in southern Spain and Portugal in 1956 in which some 180,000 sheep died. It must be recalled that, prior to this event, apparently new territorial extensions to the distribution range had occurred in Texas in 1948, in California in 1952 and in Pakistan in 1959. These outbreaks gave rise to the fear that bluetongue was a disease in the process of extending its boundaries and that checks on further spread were still not understood. The first and most elementary of the epidemiologist’s task was therefore to define the distribution. The disease known as bluetongue results from the interaction between the host, the virus and the environment. Although cattle, sheep and goats are all susceptible to bluetongue virus the appearance of clinical disease is generally restricted to fine-wool and mutton breeds of sheep which, seemingly by chance, occur in countries at the limits of the virus distribution range (Figure 1) — in Spain, Portugal, Turkey, Cyprus and South Africa. Elsewhere the disease is seen wherever similarly susceptible animals are transported to countries within the endemic area, for instance to Nigeria (1) or Cameroon (2).

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World-wide distribution of bluetongue virus

FIG. 1
However, unimproved sheep, like goats and cattle, are highly resistant to the clinical effects of infection so that the vast majority of bluetongue episodes are probably completely silent. Under these circumstances it is obvious that reliance on the appearance of clinical disease will fail, by a very large margin, to fully define the range of bluetongue virus distribution; serological approaches have been needed and have been rewarding.

Initial surveys in many different laboratories, some still in progress, using group specific tests to demonstrate the presence of the virus, have allowed us to draw a map indicating the global distribution of bluetongue virus in an equatorial belt between (roughly) parallels 40°N and 35°S. Further, positive sera can be examined in microneutralisation tests to provide information relating to the virus types present in a given area. Analysis of recent data (Table I) shows the cosmopolitan nature of many virus types. Clearly, therefore, although much detail remains unknown, the broad outlines of the virus distribution are now known.

### TABLE I

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Bluetongue is maintained in nature in an endless series of alternating cycles between *Culicoides* midges (vectors) and various mammalian species (hosts) of which cattle, sheep and goats are the most numerically important. Experimentation has shown that the ability to infect cells of the gut lumen is restricted to a limited number of species of *Culicoides* (P.S. Mellor, personal communication) and in essence, the distribution map of bluetongue is no more than a distribution map of competent insect vectors. These entomological insights coupled with a vector mapping programme have allowed us to re-examine the Mediterranean area. We can now show that the limit of the virus distribution corresponds closely with the most northerly limits of *Culicoides imicola*, the classic vector species. In other words, there is an ecological line across which bluetongue cannot naturally spread that will continue to protect southern Europe from infection — barring the accidental movement of live infected animals into the clean area. We may now claim to understand something of the maintenance mechanism and how it really does impose constraints on the unlimited spread of this virus.

Lastly we must look at the means whereby a non-contagious, insect-transmitted virus can survive within its endemic distribution range. Sellers repeatedly analysed circumstantial data to support his theory of long distance transportation of infected insects by favourable winds (3). In general this consisted of relating the sudden onset of outbreaks of insect-transmitted disease to aberrations in prevailing wind systems; producing convincing direct evidence of the migratory potential of *Culicoides* midges is a challenge that still faces us. We can, however, draw inspiration
from work conducted with other insect species such as the desert locust or the army worm moth (in the latter species adult insects have been observed to travel for several successive nights in the direction of the prevailing wind and to congregate towards areas of recent rainfall) to suggest that migration may be possible. In Malawi (Figure 2) we can see a clear link between the rainfall pattern and the period during which bluetongue is active, while in the Caribbean we have seen clear evidence for the existence of a long distance distribution mechanism (4). We can perhaps conclude that the vector, and with it the virus, is highly nomadic, moving over long distances and allowing the virus seasonal access to a constant supply of susceptible hosts.

How then have these studies been of value in facilitating trade? Obviously, the most important contribution has been to define bluetongue-free and bluetongue-infected areas and to define those areas where trade restrictions need not apply. A harder task has been to derive conditions to allow trade between infected and uninfected areas. Because of its seasonal nature, even within the endemic area, there will be periods of the year when infection is absent and, equally, at the fringes of the distribution range there will be areas where the virus only rarely occurs. Although no conclusions have been reached, a great deal of effort has been devoted to trying to facilitate the importation into Europe of cattle, semen and embryos from a group of states in the north-east of the USA where a low risk area certainly exists. One of the hardest facets of this work has been to obtain information on the movement of bluetongue virus on the North American continent or on the possible portals for the entry of new virus types. It has therefore been both profitable and exciting to link up with Louisiana State University, where Professor Martin Hugh-Jones has a computer programme that has drawn a remarkable map showing the contours of seroprevalence of bluetongue within that State. This has shown, as we had already surmised from our own field evidence, that virus “hot-spots” exist. We now need to look at the stability of these hot-spots with time and season and to relate then to insect densities.

While much remains to be discovered in unravelling the details of the epidemiology of this interesting virus the indications are that we are looking at the right aspects of the problem and the answers that will emerge will have applicability to the study of a wide range of insect-transmitted viruses.

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**ÉPIDÉMIOLOGIE DE LA FIÈVRE CATARRHALE Ovine. — W.P. Taylor.**

RÉSUMÉ : L'auteur présente les méthodes d'enquête utilisées pour établir la répartition mondiale de la fièvre catarrhale ovine et de ses sérotypes, ainsi que le rôle des insectes vecteurs dans la détermination de sa répartition. Le virus de la fièvre catarrhale ovine est décrit comme un virus mobile qui se déplace dans une zone d'enzootie à la faveur de la migration saisonnière des insectes. En fin d'article, ces aspects sont examinés dans la perspective du commerce d'ânimaux et de leurs semences ou leurs embryons.

FIG. 2
Seasonal activity of bluetongue virus in relation to rainfall

Resumen: Expone el autor los métodos de encuesta empleados para establecer la distribución mundial de la lengua azul y de sus serotipos, así como el papel de los insectos vectores en la determinación de su distribución. Se describe el virus de la lengua azul como un virus móvil que se mueve en una zona de enzootia con la migración estacional de los insectos. Al final del artículo, se examinan estos aspectos en la perspectiva del comercio de animales y de su semen o embriones.

PALABRAS CLAVE: Arbovirus - Comercio internacional - Encuestas epidemiológicas - Enfermedades de ovinos - Estación del año - Ganado - Insectos - Virus de la lengua azul.

REFERENCES