Veterinaria Italiana, **42** (2), 103-118

Description and implementation of a surveillance network for bluetongue in the Balkans and in adjoining areas of south-eastern Europe

F. Dall'Acqua, C. Paladini, R. Meiswinkel, L. Savini & P. Calistri

Summary

During the recent severe outbreaks of bluetongue (BT) in the Mediterranean Basin, the BT virus (BTV) spread beyond its historical limits into the Balkan region. One of the primary impacts of BT is the cessation in livestock trade which can have severe economic and social consequences. The authors briefly describe the development of the collaborative East-BTnet programme which aims to assist all affected and at-risk Balkan states and adjoining countries in the management of BT, and in the development of individual national surveillance systems. The beneficiary countries involved, and led by the World organisation for animal health (Office International des Épizooties) Collaborating Centre for veterinary training, epidemiology, food safety and animal welfare of the *Istituto Zooprofilattico dell'Abruzzo e del Molise 'G. Caporale'* in collaboration with the Institute for the Protection and the Security of the Citizen, the European Commission Joint Research Centre (IPSC-JRC), were Albania, Bosnia-Herzegovina, Bulgaria, Croatia, Cyprus, the Former Yugoslavia Republic of Macedonia, Kosovo, Malta, Romania, Serbia and Montenegro, Slovenia and Turkey. A regional web-based surveillance network is a valuable tool for controlling and managing transboundary animal diseases such as BT. Its implementation in the Balkan region and in adjoining areas of south-eastern Europe is described and discussed.

Keywords

Balkans, Bluetongue, *Culicoides*, Geographic information systems, Europe, Surveillance network, Web-based technologies.

Introduction

Bluetongue (BT) virus (BTV) is a member of the genus *Orbivirus* of the family *Reoviridae* and is the causative agent of BT, an infectious, non-contagious, vector-borne disease affecting primarily sheep (26). The 24 immunologically distinct serotypes of BTV are transmitted by various species of biting midges of the genus *Culicoides* (11). Although BTV infection in cattle is typically asymptomatic, the bovine plays an important role in the epidemiology of the disease as it can remain viraemic up to 63 days. (2, 4).

In the Mediterranean Basin, BT was first reported from Cyprus in 1943 (16) and subsequently in Israel (56); between 1956 and 1960, a large epidemic in Spain and Portugal caused the deaths of approximately 179 000 sheep (27). In the easterly parts of the Basin, BT appeared to be more regularly prevalent; for example, in the 1970s and 1980s it was reported almost annually in Israel (54), Cyprus, Turkey and on the Greek islands of Lesbos and Rhodes (50).

Since 1998, BT has spread phenomenally across

Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise 'G. Caporale' (OIE CC IZSA&M), Campo Boario, 64100 Teramo, Italy
World organisation for animal health (Office International des Épizooties) Collaborating Centre for Veterinary Training, Epidemiology, Food Safety and Animal Welfare

the Mediterranean Basin and onwards into the Balkan region, which represents an advance of approximately 400 km northward over previous incursions. Over the ensuing years, five serotypes of BTV i.e. BTV-1, -2, -4, -9 and -16 have invaded various countries, many for the first time (30, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49). Amongst these, Italy was most severely affected; for example during the first three seasons of the epidemic (2000-2002), the high pathogenicity of BTV-2, the high sensitivity of the Sardinian breed of sheep, and the large abundances of the principal vector (*Culicoides imicola*), led to the loss of more than 520 000 sheep (6). However, in some countries of the Balkans and eastern Mediterranean, the direct losses remained low due, in part, to the lower pathogenicity of the other serotypes and because of the lower vector capacity of the secondary vector *Culicoides*. Ultimately, all countries affected by BT suffered equally from trade restrictions because all livestock movements were banned (13).

Around the world approximately 30 species of *Culicoides* transmit BT (29). Within southern Europe, the four vectors are *C. imicola*, *C. obsoletus*, *C. scoticus* and *C. pulicaris* (8, 21, 52, 55). The first of these is an Afro-Asiatic species and accounts for approximately 90% of BT transmission. Remarkably, it was discovered to occur along the northern margin of the Mediterranean Basin only in the early 1980s and in Italy only in 2000 (19). Thus, its exact distribution within southern Europe remains incompletely known and therefore it is difficult to understand whether it is indeed moving northwards under the influence of global warming as is widely believed (50). The remaining three vectors are Palaearctic endemics and, because they occur as far north as the 60th latitude in Europe, places a significant portion of the continent at potential risk to BT. Their precise distribution and abundances and their capacity to replicate and transmit the virus remain poorly understood. These nocturnally-active insects are collected using Onderstepoort-type blacklight traps, which rapidly provide information on the occurrence and abundances of *Culicoides* on livestock farms. If such collections are made in tandem with the recording of climatic variables using automatic weather stations, then much can also be learned about their seasonal activity periods. Such information is essential to the production of BT risk maps, the more sophisticated of which employ satellite imagery.

Bluetongue can be a costly infection for several reasons. In sheep, the disease can result in death, weight loss and wool break. However, the greatest cost is incurred by the embargo on trade in live animals, embryos, ova and semen (15). For example, it has been estimated that the ban on cattle semen exports from the USA in the late 1970s resulted in an annual loss of US$24 million (15, 17). The total animal population in the Balkanic states is approximately 18 million sheep and goats and 7 million cattle (14). The need to support the agricultural and food safety systems in these countries, and to reduce rural poverty, is reflected in the aims and priorities promulgated recently in the Italian law 84/2001 (1).

Bluetongue cannot be controlled through a ban on animal movements only because the insect vector is able to cross national boundaries. Therefore, measures taken at the national level depend upon them also being adopted by neighbouring countries. As a consequence of the recent outbreaks of BT in southern Europe, the representatives of the affected and at-risk countries expressed a need to implement a regional surveillance network. This led to the design of the project 'Cooperation for implementing a surveillance network for bluetongue in the Balkanic area' (East-BTnet). It commenced in May 2004.

The participating countries were Albania,

Bosnia-Herzegovina, Bulgaria, Croatia, Cyprus, the Former Yugoslavia Republic of Macedonia, Kosovo, Malta, Romania, Serbia and Montenegro, Slovenia and Turkey. Croatia and Romania were selected as pilot countries as they had already initiated their own surveillance programmes (24, 25; A. Ionescu, personal communication).

The principal objective was to standardise measures for the harmonisation of this regional surveillance network so that national veterinary authorities could respond in real-time to an incursion and subsequent spread of the disease or infection also using geographic information systems (GIS) technologies. The system was designed to give a clear regional picture of the distribution of BT and to provide a common source of data for further analyses and information exchange. The steps taken to implement this surveillance network at the regional level and the context and strengths of East-BTnet are described. Finally, future plans for the continued expansion of the surveillance system are considered.

Materials and methods

Assessment of current bluetongue surveillance systems

The establishment of a regional surveillance network for BT and the preparation of common standardised procedures at a regional level require knowledge of the following:

- existing surveillance systems
- necessary diagnostic equipment and reagents
- skills and training needs
- availability of hardware and software for data management and epidemiological analysis.

To obtain this background information, a questionnaire was sent to the representatives of national veterinary services in March 2004 and was divided into four sections, as described below.

Section A: Disease surveillance

This part of the questionnaire requested information on the ability of a country to recognise the disease and enquired whether a clinical surveillance programme was already in place; if so, the type of information collected and, in the event of clinical outbreaks, the type of laboratory tests employed.

Section B: Entomological surveillance

Section B requested information on the existing *Culicoides* surveillance programme, i.e. the type, number and distribution of light traps used, the seasonality, distribution and frequency of sample collection, the data recorded and laboratory capacity for subsequent analysis and identification.

Section C: Serological surveillance

Section C requested information on the existing serology surveillance programme, i.e. the type of surveillance, the animal species targeted, the seasonality, distribution and frequency of sample collection, the type of data recorded at blood sampling and the types of tests employed in laboratories.

Section D: Information system

Section D requested information on the type of software employed to store, collect, collate and analyse data, how the information is disseminated and the hierarchical positions of personnel involved in BT surveillance.

A summary of the type of information sought is shown in Table I.

Establishing the level of training required and the laboratory equipment needed, including hardware and software for BT surveillance, was performed by visiting two pilot countries (Croatia and Romania) and by holding a total of seven workshops in Croatia, Cyprus, Greece, Italy, Romania and Turkey.

Standardisation of common procedures

Based on the experience acquired during the extensive outbreaks of BT in Italy, standardised entomological and serological procedures were

Vol. 42 (2), Vet Ital

Table I
Categories of information requested in the bluetongue needs assessment questionnaire

Section A Disease surveillance	Section B Entomological surveillance	Section C Serological surveillance	Section D Information system
Is BT a notifiable disease in your country? Has a BT clinical surveillance programme been implemented? If so, where is surveillance being conducted? –throughout the country –close to the border of risk or of an infected zone –in infected zones only –elsewhere What type of information is recorded in a clinical outbreak? –unique farm identification code –date of visit –date of clinical onset of BT –number of susceptible animals present on the farm –animal species present on the farm –number of sick animals –number of dead animals –number of slaughtered animals –type of animal specimens (blood or organ) collected –insect collections	Has any entomological surveillance been implemented? Type of blacklight traps being used: –Onderstepoort-type –others When is the light trap being operated? –throughout the year –seasonally How often are light trap collections made? –daily –weekly –fortnightly –monthly What type of information is recorded for each insect collection? –unique farm identification code –date of capture –animal species present on the farm –number of susceptible animals on the farm –maximum temperature during the night of capture –minimum temperature during the night of capture Where are the entomological samples sent to? – a national laboratory – a foreign laboratory What information is recorded during insect identification? –presence/absence of *Culicoides* spp. –total number of insects –total number of *Culicoides* –total number of *C. imicola* –total number of Obsoletus Complex –total number of Pulicaris Complex	Has a serological surveillance system been implemented? If so, what type of system was implemented? –a sentinel system and/or –a periodical system Which livestock species are being tested? Where is surveillance conducted? –throughout the country –close to the border of risk or to infected zones –in infected zones When is serological surveillance conducted? –throughout the year –seasonally How often are the animals bled? –weekly –fortnightly –monthly What information is recorded for each blood sample? –farm address –unique farm identification code –date of sample collection –animal species present on the farm –ID code of each animal –age of animal What type of serological and virological tests are used? –c-ELISA –agar gel immunodiffusion –virus neutralisation –polymerase chain reaction –virus isolation Where are the serological samples sent to? –a national laboratory –a foreign laboratory	Has an information system been implemented? How is the geographic position of farms and traps determined? –by geographic position system –using maps –other What type of software is used to analyse data: –Microsoft Excel® –Microsoft Access® –geographic information systems softwares (ArcView®, ArcGis®, MapGuide)® – STATA 7.0® –other Is any extra information being collected: –climatic variables –environmental data –soil samples Are results released to stakeholders? How are surveillance results circulated? –in paper-based newsletters or bulletins –through the internet –in published scientific papers –in monthly reports –in the media –at congresses

BT bluetongue

developed to facilitate the analysis and comparison of the extensive data acquired. For the entomological programme, a reference geographical unit of 400 km^2 was used, in which one blacklight trap for the capture of *Culicoides* would be operated weekly. Moreover, the detailed protocol for the setting of blacklight traps near livestock was defined. Choice of site, sample collection, equipment and sample analysis are given in Goffredo and Meiswinkel (20). For the serological programme, the diagnostic tests and kits to be used were recommended and different surveillance schemes suggested i.e. a sentinel system based on the use of the same negative animals and/or a periodical survey of susceptible livestock populations. To compare data generated from the different national surveillance systems, standardised entomological and serological sample data collection forms were developed. Subsequently, to combine the entomological and serological data sets, an information system was implemented. This includes the structure and the format of the records (coding line) and the type of data needed to update the system. The system comprises compulsory and optional fields. Under the former is included country, administrative boundary, date of sample collection and unique identification farm code. For serological surveillance, the type of survey, type of test/s, number of tested and positive animals, serotype/s and animal species were requested. For entomological surveillance, the total number was requested for: insects, *Culicoides* spp., *C. imicola*, Obsoletus Complex and Pulicaris Complex. The latter included farm/site denomination, altitude, latitude, longitude and maximum and minimum temperature of the night of insect capture (Table I).

Implementation of East-BTnet website

A web-based surveillance network (www.east-btnet.izs.it) was planned and implemented to harmonise the collection and the management of epidemiological data generated by the veterinary services of participating countries. The website is divided into different sections (Fig. 1), as follows:

- East-BTnet project
- legislation
- document resources
- training documents
- maps
- discussion forum
- archive slide presentations
- links.

The website is accessed simply via a generic internet browser and is in the public domain; no password is required except for the entomological and serological surveillance data in the map section, the discussion forum and the archive slide presentation sections. A username and password were given to authorised users (representatives of the participating countries and personnel from the World organisation for animal health [Office International des Épizooties] Collaborating Centre for veterinary training, epidemiology, food safety and animal welfare of the Istituto Zooprofilattico dell'Abruzzo e del Molise 'G. Caporale' [OIE CC-IZSA&M]). These users gain access only to data of their own geographic jurisdiction for viewing and updating purposes. The system administrator (OIE CC-IZSA&M) has full access to the database.

Public access enables the following:

- the web page on general disease information, legislation and technical documents and scientific papers is in either Microsoft® Word or in Adobe® pdf
- training documents
- a dynamic map section displaying the annual geographic distribution of BTV serotypes. The source of these data is the OIE weekly *Disease Information*; the OIE CC-IZSA&M is responsible for updating this database.

The database on serological and entomological

a) East-BTnet project where the following documents are available: (i) project description, (ii) forms for entomological and serological sample collections, (iii) questionnaire layout of needs assessment, (iv) final report on needs assessment, (v) final workshop and evaluation of the project
b) Legislation where it is possible to consult the updated EU legislation and the OIE standards on BT
c) Document resources provide: (i) technical disease card, (ii) a photo gallery of disease symptoms and pathology, (iii) a detailed list of publications, (iv) selected articles on BT
d) Training documents on the various aspects surrounding the epidemiology and the surveillance of BT
e) Maps on serological and entomological surveillance activities
f) Discussion forum where questions on BT legislation, epidemiology, vector biology, clinical and diagnostic aspects are shared
g) Archive slide presentations where authorised users can upload and download Power Point presentations on any aspects of BT
h) Links to online scientific reviews and GIS information

Figure 1
General overview of the East-BTnet website sections

activities is updated by the authorised personnel of each country; the same web application is used to input data and the information is displayed both in tables and in maps. Moreover, a 'Help' file was created assisting the user, via examples, to understand the characteristics and functions of the GIS tools and to update the relevant web pages.

Supporting activities

Training courses

A series of training workshops on BT were organised for the veterinary personnel of all countries. These included training in the following areas:

- epidemiology
- serology and virology
- biology and identification of *Culicoides*
- the use of GIS and of the global positioning system (GPS)
- the use and positioning of automatic weather stations
- the use and positioning of blacklight trap for the capture of *Culicoides*.

Equipment

The diagnostic equipment to perform entomological, virological and serological tests was purchased by the OIE CC-IZSA&M and delivered to the pilot countries in accordance with a previous needs assessment. Laboratory equipment, such as stereoscopes, microscopes, multi-channel pipettes, sonicators, water baths, CO_2 incubators, refrigerators and egg candling lamps etc., were supplied. Moreover, automatic weather stations, with the appropriate software and sensors for air temperature, relative humidity, wind speed and direction, soil temperature and humidity were provided. In addition, hardware and software, both for geographic data analysis and for managing epidemiological data, were supplied. All the equipment was installed and tested in the laboratories and in the epidemiological units. Finally, Onderstepoort-type blacklight traps and GPSs were supplied to all participating countries.

Results

Assessment of bluetongue surveillance systems in place

The needs assessment questionnaire revealed the BT surveillance activities in the twelve countries were not homogeneous.

Section A: Disease surveillance

In all these countries, BT was notifiable, even if not all had implemented a clinical surveillance programme. There was a combination of different types of surveillance activities conducted at various levels: across the entire country (8 out of 12), close to the border of infected zones (4/12) or/and in infected zones (4/12). Moreover, in the case of clinical outbreaks, the basic information systematically collected was as follows: date of visit and of clinical onset, animal species, number of susceptible animals present on the farm, number of sick/dead/slaughtered animals and nature of clinical specimens collected.

Section B: Entomological surveillance

Six of the twelve countries had already implemented an entomological surveillance programme even if the intensity of the activities differed substantially amongst them. The type of trap used was the Onderstepoort blacklight trap that was operated mostly seasonally and in one instance throughout the year. In addition, the insect samples were collected at different intervals (daily, weekly, fortnightly or monthly). Only in a few countries did some level of expertise exist in the identification of *Culicoides*. Those without equipped laboratories and expertise sent their samples to foreign laboratories. The information recorded for each insect capture was as follows: date of capture, species and number of animals present on the farm, and maximum and minimum temperatures of the night of capture. Moreover, after sample identification, the information recorded was the total number of insects, *Culicoides*, *C. imicola*, Obsoletus and Pulicaris Complexes.

Section C: Serological surveillance

All countries, except one, conducted serological surveys at different intensities: fortnightly (1/12), monthly (5/12), occasionally (4/12) or during other disease eradication campaigns (1/12). Some countries (8/12) collected only random blood samples, whereas others (3/12) had, in addition, a sentinel network for periodic testing. Depending on the aims, the programmes were either seasonal (5/12) or throughout the year (6/12) and were conducted either across the entire territory (7/12), close to the border of infected zones (2/12) and/or in infected zones (3/12). Regarding diagnostic capabilities, the countries that conducted serological surveys used the c-ELISA test; some of them (4/12) also used agar gel immunodiffusion (AGID) and a couple (2/12) performed the virus neutralisation test. Few countries (4/12) had laboratories equipped for virus isolation, or for performing virus neutralisation tests (2/12) and the polymerase chain reaction (PCR) test (1/12). Countries with no facilities sent their samples to international reference laboratories.

Section D: Information system

Almost all countries (11/12) collected information regarding clinical, serological and entomological surveillance of BT and stored it on paper (9/12) and on computer (11/12) using different types of software, i.e. Microsoft® Excel (6/12), Microsoft® Access (2/12), STATA® 7.0 (1/12), Microsoft® FoxPro® (1/12) and Microsoft® FoxPlus (1/12). GIS software was used in three countries. To identify the geographic position of farms, either a handheld GPS (2/12) or maps (6/12) were employed.

Training courses

All countries expressed the need to strengthen their expertise in different aspects of BT (epidemiology, clinical surveillance, entomology, virology and serology) and so requested and participated in the national and international training courses, as follows:

- diagnostic capabilities, both for serological/virological and for entomological activities
- epidemiological surveillance
- capabilities on GIS.

The topics of the training courses are shown in Table II. The teaching material can be downloaded from the website in the 'training documents' section.

Implementation of the website

The website (www.east-btnet.izs.it) allows one to:

- share information on BT; the dynamic interactive web pages (dhtml) have many links that include general information on the project, on the European Union (EU) legislation, OIE standards and a general overview on BT; an interactive discussion forum is also included
- access online published and unpublished documents on BT
- input epidemiologically relevant data on the geographic distribution of BTV serotypes and *Culicoides* species
- query the databases and use GIS tools.

The functions described above are available on the website (Fig.1) in the following sections listed below.

East-BTnet project

In this section (Fig. 1a) the available documents are as follows:

- project description
- standard forms for entomological and serological sample collections
- questionnaire layout of needs assessment
- final report on needs assessment
- final workshop and evaluation of the project.

Legislation

Here the user can consult the updated EU legislation and OIE standards on BT (Fig. 1b).

Document resources

An overview of BT (epidemiology, symptoms, pathological findings, diagnosis and prophylaxis) is available (Fig.1c). A short movie and a photo gallery of disease symptoms and pathology are provided. A detailed list of publications, from 1998 to 2004, on different aspects of the disease is accessible. Furthermore, selected articles on BT are available in full length and can be downloaded in pdf format.

Training documents

Training documents on the various aspects surrounding the epidemiology and the surveillance of BT can be downloaded in Power Point® (Fig.1d). Topic details discussed during the workshops with veterinary services personnel are listed in Table II.

Maps

A web-based GIS network was developed and implemented to provide the veterinary services

Table II
Training courses for veterinary services personnel on various aspects of bluetongue

Course	Details
Epidemiology	The epidemiology of BT: a world perspective BT disease control strategies European Union and Italian legislation on BT Discussion of recent amendments to the chapter on BT in the *Terrestrial animal health code* Geographic distribution of BT in the Mediterranean Basin Entomological surveillance protocols for BT Laboratory and in-field protocols for the surveillance of BT
Entomology	The biology and ecology of *Culicoides* biting midges with emphasis on *C. imicola*, *C. obsoletus* and *C. pulicaris* Practical demonstration in the use of blacklight traps and criteria for selecting trap sites in the farmyard Laboratory management of insect samples: labelling, sub-sampling and input on computer of data *Culicoides* identification and taxonomy with emphasis on *C. imicola*, *C. obsoletus* and *C. pulicaris* Climate and environmental changes: effects of climate and soil on *Culicoides* distribution and abundance Geographic and seasonal mapping of *Culicoides* distribution and abundance
Virology and serology	Setting up and interpreting the virus neutralisation laboratory test Preparation of Vero and C6/36 cells for the isolation of BTV BTV isolation: preparation of samples for first and second passages BTV isolation: tissue cultures Immunofluorescence test
Geographic information system and the geographic positioning system	GIS and GPS: veterinary application of these tools and their importance for modelling BT GIS and GPS: description and use of these tools GIS: its definition and steps for its development and implementation GIS: installation and use of software for geographic data analysis (ArcExplorer®, GeoDa® and ArcGis®) GIS: practical sessions on creating a database and its management GPS: practical in-field demonstrations
Automatic weather station	Description of the AWS and its sensors (temperature, wind speed, wind direction, relative humidity, soil moisture and temperature) On-site installation of an AWS Practical demonstrations in the use of the AWS Maintenance of the AWS and its sensors Use of the software BoxCar® Pro. version 4.3. for time-interval downloading of climatic data The importance of the AWS for modelling the distribution of *Culicoides* vectors in areas at risk

BT bluetongue
BTV bluetongue virus
GIS geographic information system
GPS geographic positioning system
AWS automatic weather station

with an efficient tool for the management and analysis of data and the dissemination of information relevant to BT (Fig. 1e). These are described in greater detail in Savini *et al.* (53) and because a common and standardised epidemiological surveillance strategy was needed, the system was centralised. Features in the interactive thematic maps will match a country and administrative boundary or a geographic point (if the geographic coordinates of the light trap are recorded in the system). Data entered newly online are displayed in real time both in tabular and map format.

Three different ArcIMS™ projects were developed (Fig. 2) to show disease distribution, serological results and entomological results, as described below.

- Disease distribution: an overview of the annual geographic distribution of each BTV serotype is mapped for each country (public access) (Fig. 2a). The OIE CC-IZSA&M is responsible for updating this database; the data source is the OIE weekly *Disease Information*.
- Serological surveillance results: an overview of the results of serological surveillance plans of each country is presented in a dynamic map (only for authorised users) (Fig.2b). The user can retrieve alphanumerical and geographic data including the number of tested and positive animals, animal species and type of tests performed. Data are retrieved by year, month and geographic unit.
- Entomological surveillance results: an overview of the entomological activities performed within a specific geographic area is provided (only for authorised users) (Fig. 2c). By selecting individual layers in the database the geographic distribution (presence / absence) of *Culicoides* species, the maximum number of *Culicoides* caught, and the total number of *Culicoides* species (*C. imicola*, Obsoletus and Pulicaris Complexes) collected within a selected administrative boundary, can be tracked. The maximum and minimum temperatures on the night of capture and geographic coordinates of the light trap are also recorded.

Discussion forum

In this section, ideas, questions and problems on BT are shared by users via a web-based message system (Fig.1f). The user can read all messages on the discussion topics and can participate in the forum in the following topics: legislation, epidemiology, vector biology, clinical aspects and diagnostic aspects.

Archive of slide presentations

Authorised users can upload and download Power Point® presentations on any aspects of BT which they may wish to share with colleagues (Fig. 1g).

Links

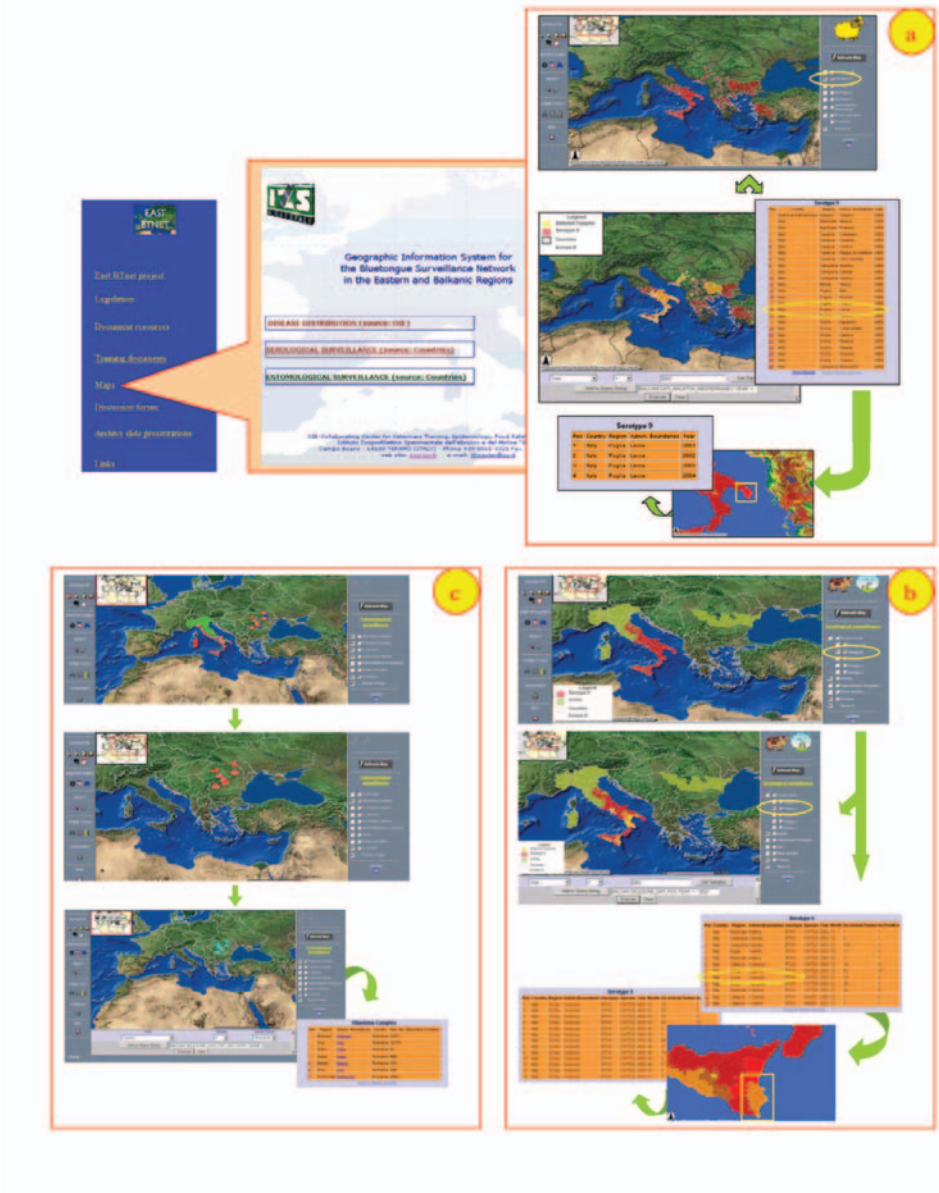
A list of links to other web pages is provided to facilitate the retrieval of information on satellite data, on-line scientific reviews and GIS tools (Fig. 1h).

Discussion

A web-based surveillance network, like East-BTnet, is a novel approach for monitoring patterns of virus and vector distributions. It facilitates the rapid collection, analysis, interpretation and dissemination of large quantities of data that will be generated by monitoring programmes in various countries within different environments. Moreover, real-time dynamic maps can be generated in response to shifts in the distribution of the virus (7).

This approach is yet to be used more widely in the veterinary field (7, 9, 12, 18, 22, 28), despite its already extensive application in existing worldwide human health domains (3, 5, 10, 23, 31, 51).

When a regional surveillance network is implemented, and when faced with a transboundary phenomenon like BT, it is essential to adopt a holistic approach (55) that is adaptable to the



a) Disease distribution: geographic distribution of BTV serotype 9 in 2002 with an esample of hyperlink data i.e. records, country, region, administrative boundary and year are displayed (data retrieved from the OIE)
b) Serological surveillance: geographic distribution of BTV serotype 9 in 2002, with an example of hyperlink data displayed with extra details i.e. animal species, total number of tested and positive animals, serotype and month (East-BTnet data source)
c) Entomological surveillance: geographic distribution (hypothetical) of *Culicoides obsoletus* specie Complex in Romania with an example of hyperlink data displayed of the selected geo-unit (East-BTnet data source)

Figure 2
Map section of the East-BTnet website

indigenous livestock practices which can differ from one country to the next. Prior to the establishment of the East-BTnet, the existing surveillance programmes were neither homogeneous nor harmonised amongst the countries; thus the data were not comparable and gave only a partial view of the BT situation within each given area. Consequently, it was necessary to develop a common approach for the control of BT. The web-based instrument developed for East-BTnet not only provides the veterinary services of participating countries with a useful tool for managing, analysing and sharing epidemiological data, but also facilitates the harmonisation of the surveillance strategies through the standardisation of the data collected by the information systems. The implementation of the system network required a delicate preliminary phase where the needs (i.e. extant knowledge, laboratory equipment, informatics tools, etc.) of each country had to be identified first and this was done through a questionnaire and visits to the pilot countries. This phase helped to pinpoint weaknesses in the exsisting systems and to address and strengthen them, based upon individual needs. The disease surveillance section of the questionnaire highlighted the importance and the threat of BT to the extent that some countries implemented a clinical surveillance programme even if they had not experienced the disease (i.e. Romania).

Simultaneously, a dire need for strengthening the entomological surveillance activities in nearly all the Balkan countries was identified. Accordingly, extensive light trapping programmes for *Culicoides*-biting midges have been and continue to be instituted in various countries. This will facilitate further elucidation of the epidemiology of BT by providing a more intimate understanding of the distribution and abundances of the various vector species involved. Furthermore, the standardised methodologies implemented (i.e. based on the collection of a minimum set of data) provide information on the following:

- early detection of BTV circulation by regularly testing large numbers of livestock
- identification of which BTV serotypes are circulating
- evaluation of the sanitary status of susceptible animal populations
- identification of seasonally free areas.

The training provided in the workshops laid a good foundation and created a close-knit network for the continuous exchange of ideas, doubts and problems on various aspects of BT.

The East-BTnet website gives an immediate bird's eye view of the current BT situation by integrating entomological and serological data and other sources of information. It is a powerful tool that can also be used to design national surveillance systems, to collect more detailed data and to seek and obtain information that otherwise would not be available. In this way, knowledge can be shared amongst countries, and user-friendly solutions provided via the internet using GIS technologies. Additionally, it is a positive step towards building a valuable historical database for future risk analysis studies, not only for BT but also for African horse sickness. Furthermore, it can be tailored easily for other vector-borne diseases such as West Nile fever and Crimean-Congo haemorrhagic fever. Finally, it is envisaged that this surveillance network will, in the near future, be extended eastwards across an even larger geographic area, which will be supported by an already existing reference centre providing not only training but also assistance in the analysis and dissemination of information.

Acknowledgements

Sincere thanks are extended to the following personnel of the Institute for the Protection and

the Security of the Citizen, the European Commission Joint Research Centre (IPSC-JRC), Italy: James Bishop, Gianluca Fiore, Christophe Korn, Sergio Mainetti, Ugo Meloni, Silvia Parnisari, André Poucet, Espedito Ruotolo and Irene Solinas for their collaborative support and technical assistance during the workshops. From the IZSA&M, we thank Annamaria Conte, Maria Goffredo, Carla Ippoliti, Mario Parisse, Giovanni Savini and Daniele Zippo, who were involved in the development of the East-BTnet project and in subsequent training programmes. Special thanks are extended to the veterinary services of Albania, Bosnia-Herzegovina, Bulgaria, Cyprus, Croatia, the Former Yugoslavia Republic of Macedonia, Kosovo, Malta, Serbia and Montenegro, Slovenia, Romania and Turkey for their enthusiastic collaboration.

Grant support

This project was promoted by the Abruzzo Region and funded by the Italian Ministry of Foreign Affairs under the provisions of Law 84/2001 regarding Italian cooperation in the Balkanic Region. Its implementation was entrusted to the OIE CC-IZSA&M with the IPSC-JRC as collaborating partner. Cyprus, Kosovo, Malta, Slovenia and Turkey participated with the financial support of the IPSC-JRC.

References

1. Anon. 2001. Legge n. 84 del 21 marzo 2001. Disposizioni per la partecipazione italiana alla stabilizzazione, alla ricostruzione e allo sviluppo di Paesi dell'area Balcanica. *Gazz Uff Rep Ital*, **76**, 31 March.
2. Barratt-Boyes S.M. & MacLachlan N.J. 1995. Pathogenesis of bluetongue virus infection of cattle. *J Am Vet Med Assoc*, **206**, 1322-1329.
3. Bédard Y., Gosselin P., Rivest S., Proulx M.J., Nadeau M., Lebel G. & Gagnon M.F. 2003. Integrating GIS components with knowledge discovery technology for environmental health decision support. *Int J Med Informatics*, **70** (1), 79-94.
4. Bonneau K.R., DeMaula C.D., Mullens B.A. & MacLachlan N.J. 2002. Duration of viraemia infectious to *Culicoides sonorensis* in bluetongue virus-infected cattle and sheep. *Vet Microbiol*, **88** (2), 115-125.
5. Boulos M.N.K. 2004. Towards evidence-based, GIS-driven national spatial health information infrastructure and surveillance services in the United Kingdom. *Int J Health Geogr*, **3** (1)(www.ij-healthgeographics.com/content/3/1/1 accessed on 5 April 2006).
6. Calistri P., Giovannini A., Conte A., Nannini D., Santucci U., Patta C., Rolesu S. & Caporale V. 2004. Bluetongue in Italy: Part I. *In* Bluetongue, Part I (N.J. MacLachlan & J.E. Pearson, eds). Proc. Third International Symposium, Taormina, 26-29 October 2003. *Vet Ital*, **40** (3), 243-251.
7. Cameron A.R. 2004. Data management and analysis systems for bluetongue virus zoning in Australia. *In* Bluetongue, Part I (N.J. MacLachlan & J.E. Pearson, eds). Proc. Third International Symposium, Taormina, 26-29 October 2003. *Vet Ital*, **40** (3), 365-368.
8. Caracappa S., Torina A., Guercio A., Vitale F., Calabro A., Purpari G., Ferrantelli V., Vitale M. & Mellor P.S. 2003. Identification of a novel bluetongue virus vector species of *Culicoides* in Sicily. *Vet Rec*, **153** (3), 71-74.
9. Conte A., Colangeli P., Ippoliti C., Paladini C., Ambrosini M., Savini L., Dall'Acqua F. & Calistri P. 2005. The use of a Web-based interactive geographical information system for the surveillance of bluetongue in Italy, *Rev Sci Tech*, **24** (3), 857-868.
10. Croner C.M. 2003. Public health, GIS and the Internet. *Ann Rev Publ Health*, **24**, 57-82.

11. Du Toit R.M. 1944. The transmission of bluetongue and horse sickness by *Culicoides*. *Onderstepoort J Vet Sci Anim Ind*, **19**, 7-16.
12. Egbert M. 2004. Web-based disease tracking: a West Nile virus example (gis.esri.com/library/userconf/proc04/docs/pap1131.pdf accessed on 5 April 2006).
13. European Council 2000. Directive 2000/75/EC of 20 November 2000 laying down specific provisions for the control and eradication of bluetongue. *Off J*, **L 327**, 74-83.
14. Food and Agriculture Organization (FAO) 2004. Global livestock production and health atlas, all livestock, density, land area. FAO, Rome (www.fao.org/ag/aga/glipha/index.jsp accessed on 5 April 2006).
15. Food and Agriculture Organization (FAO) Agriculture Department, Animal Production and Health Division (AGA) 2006. Disease cards: bluetongue. FAO, Rome (www.fao.org/ag/againfo/subjects/en/health/diseases-cards/bluetongue.html accessed on 13 April 2006).
16. Gambles R.M. 1949. Bluetongue of sheep in Cyprus. *J Comp Pathol*, **59**, 176-190.
17. Gibbs E.P.J. & Greiner E.C. 1989. Bluetongue and epizootic hemorrhagic disease. *In* The arboviruses: epidemiology and ecology, Vol. 2. (T. P. Monath, ed.). CRC Press, Inc., Boca Raton, Florida, 30-70.
18. Giovannini A., Paladini C., Calistri P., Conte A., Colangeli P., Santucci U., Nannini D. & Caporale V. 2004. Surveillance system of bluetongue in Italy. *In* Bluetongue, Part I (N.J. MacLachlan & J.E. Pearson, eds). Proc. Third International Symposium, Taormina, 26-29 October 2003. *Vet Ital*, **40** (3), 369-384.
19. Goffredo M., Satta G., Torina A., Federico G., Scaramozzino M., Cafiero M.A., Lelli R. & Meiswinkel R. 2001. The 2000 bluetongue virus (BTV) outbreak in Italy: distribution and abundance of the principal vector *Culicoides imicola* Kieffer. *In* Proc. 10th International Symposium of the American Association of Veterinary Laboratory Diagnosticians (AAVLD) and OIE Seminar on biotechnology, Salsomaggiore, Parma, 4-7 July. AAVLD, Ames, 308-309.
20. Goffredo M. & Meiswinkel R. 2004. Entomological surveillance of bluetongue in Italy: methods of capture, catch analysis and identification of *Culicoides* biting midges. *In* Bluetongue, Part I (N.J. MacLachlan & J.E. Pearson, eds). Proc. Third International Symposium, Taormina, 26-29 October 2003. *Vet Ital*, **40** (3), 260-265.
21. Gomulski L.M., Meiswinkel R., Delécolle J-C., Goffredo M. & Gasperi G. 2005. Phylogenetic relationships of the subgenus *Avaritia* Fox, 1955 including *Culicoides obsoletus* (Diptera, Ceratopogonidae) in Italy based on internal transcribed spacer 2 ribosomal DNA sequences. *Systematic Entomol*, **30** (4), 619-631.
22. Gosselin P., Lebel G., Rivest S. & Douville-Fradet M. 2005. The integrated system for public health monitoring of West Nile virus (ISPHM-WNV): a real-time GIS for surveillance and decision-making. *Int J Health Geogr*, **4**, 21 (http://www.ij-healthgeographics.com/content/4/1/21 accessed on 13 April 2006).
23. Hanchette C.L., Gibbs D.A., Gilliam A., Fogarty K.J. & Bruhn M. 2005. A national, geographic database of CDC-funded HIV prevention services: development challenges and potential applications. *Int J Health Geogr*, **4**, 28 (www.ij-healthgeographiHealths.com/content/4/1/28 accessed on 13 April 2006).
24. Labrovic A., Poljak Z., Šeparović S., Jukic B., Lukman D., Listeš E. & Bosnić S. 2004. Spatial distribution of bluetongue in cattle in southern Croatia in the last quarter of 2002. *In* Bluetongue, Part I (N.J. MacLachlan & J.E. Pearson, eds). Proc. Third International Symposium, Taormina, 26-29 October 2003. *Vet Ital*, **40** (3), 217-220.
25. Listeš E., Bosnić S., Benić M., Lojkić M., Čać Ž., Cvetnić Ž., Madić J., Šeparović S., Labrović A.,

Savini G. & Goffredo M. 2004. Serological evidence of bluetongue and a preliminary entomology study in southern Croatia. *In* Bluetongue, Part I (N.J. MacLachlan & J.E. Pearson, eds). Proc. Third International Symposium, Taormina, 26-29 October 2003. *Vet Ital*, **40** (3), 221-225.

26. MacLachlan N.J. 1994. The pathogenesis and immunology of bluetongue virus infection of ruminants. *Comp Immunol Microbiol Infect Dis*, **17**, 197-206.
27. Manso-Ribeiro J., Rosa-Azevedo J.A., Noronha F.O., Braco-Forte M.C., Grave-Pereira C. & Vasco-Fernandez M. 1957. Fièvre catarrhale du mouton (bluetongue). *Bull Off Int Epiz*, **48**, 350-367.
28. Maroney S.A. & Freier E.J. 2004. Controlling livestock diseases with the help of an interactive map server (gis.esri.com/library/userconf/proc01/professional/abstracts/a602.html accessed on 5 April 2006).
29. Meiswinkel R., Gomulski L.M., Delécolle J-C., Goffredo M. & Gasperi G. 2004. The taxonomy of *Culicoides* vector complexes – unfinished business. *In* Bluetongue, Part I (N.J. MacLachlan & J.E. Pearson, eds). Proc. Third International Symposium, Taormina, 26-29 October 2003. *Vet Ital*, **40** (3), 151-159.
30. Mellor P.S. & Wittmann E.J. 2002. Bluetongue virus in the Mediterranean Basin 1998-2001. *Vet J*, **164** (1), 20-37.
31. Moreno-Sanchez R., Hayden M., Janes C. & Anderson G. 2005. A web-based multimedia spatial information system to document *Aedes aegypti* breeding sites and dengue fever risk along the US-Mexico border. *Health Place* (doi:10.1016/j.healthplace.2005.10.001), Article in Press.
32. Office International des Épizooties 1998. Bluetongue in Greece. *Dis Info*, 27 November, **11** (47), 166.
33. Office International des Épizooties 1999. Bluetongue in Bulgaria. *Dis Info*, 9 July, **12** (26), 94.
34. Office International des Épizooties 2000. Bluetongue in Algeria. *Dis Info*, 28 July, **13** (28), 109.
35. Office International des Épizooties 2000. Bluetongue in France: in the island of Corsica. *Dis Info*, 3 November, **13** (43), 195.
36. Office International des Épizooties 2000. Bluetongue in Italy. *Dis Info*, 1 September, **13** (34), 150.
37. Office International des Épizooties 2000. Bluetongue in Spain: in the Balearic Islands. *Dis Info*, 13 October, **13** (40), 181.
38. Office International des Épizooties 2000. Bluetongue in Tunisia. *Dis Info*, 7 January, **13** (1), 1.
39. Office International des Épizooties 2001. Bluetongue in Croatia. *Dis Info*, 21 December, **14** (51), 291.
40. Office International des Épizooties 2001. Bluetongue in Former Yugoslav Republic of Macedonia. *Dis Info*, 12 October, **14**(41), 234.
41. Office International des Épizooties 2001. Bluetongue in Kosovo (FRY), territory under United Nations interim administration. *Dis Info*, 12 October, **14** (41), 242.
42. Office International des Épizooties 2001. Bluetongue in Yugoslavia. *Dis Info*, 2 November, **14** (44), 252.
43. Office International des Épizooties 2002. Bluetongue in Bosnia and Herzegovina. *Dis Info*, 6 September, **15** (36), 171.
44. Office International des Épizooties 2003. Bluetongue in Albania. *Dis Info*, 14 February, **16** (7), 47.
45. Office International des Épizooties 2004. Bluetongue in Cyprus. *Dis Info*, 19 March, **17** (12), 83-84.
46. Office International des Épizooties 2004. Bluetongue in Morocco. *Dis Info*, 24 September, **17** (39), 273.
47. Office International des Épizooties 2004. Bluetongue in Portugal. *Dis Info*, 26 November, **17** (48), 353.
48. Office International des Épizooties 2004. Bluetongue in Spain: serological findings in the peninsular territory, in sentinel animals. *Dis Info*, 15 October, **17** (42), 302.
49. Office International des Épizooties 1999. Bluetongue in Turkey. *Dis Info*, 6 August, **12** (30), 107.
50. Purse B.V., Mellor P., Rogers D.J., Samuel A.R., Mertens P.P.C. & Baylis M. 2005. Climate change and the recent emergence of bluetongue in Europe. *Nat Rev Microbiol*, **3**, 171-180.

51. Rolfhamre P., Grabowska K. & Ekdahl K. 2004. Implementing a public web based GIS service for feedback of surveillance data on communicable diseases in Sweden. *BMC Infect Dis*, **4**, 17 (www.biomedcentral.com/content/pdf/1471-2334-4-17.pdf accessed on 13 April 2006).

52. Savini G., Goffredo M., Monaco F., Di Gennaro A., Cafiero M.A., Baldi L., De Santis P., Meiswinkel R. & Caporale V. 2005. Bluetongue virus isolations from midges belonging to the Obsoletus complex (*Culicoides*, Diptera: Ceratopogonidae) in Italy. *Vet Rec*, **157** (5), 133-139.

53. Savini L., Ippoliti C., Conte A., Parisse M., Dall'Acqua F. & Calistri P. 2006. Development of a web-based geographic information system for the epidemiological surveillance of bluetongue in the Balkan and Eastern Mediterranean countries. *Vet Ital*, **42** (3) (accepted for publication).

54. Shimshony A. 2004. Bluetongue in Israel – a brief historical overview. *In* Bluetongue, Part I (N.J. MacLachlan & J.E. Pearson, eds). Proc. Third International Symposium, Taormina, 26-29 October 2003. *Vet Ital*, **40** (3), 116-118.

55. Tabachnick W.J. 2004. *Culicoides* and the global epidemiology of bluetongue virus infection. *In* Bluetongue, Part I (N.J. MacLachlan & J.E. Pearson, eds). Proc. Third International Symposium, Taormina, 26-29 October 2003. *Vet Ital*, **40** (3), 145-150.

56. Verwoerd D.W. & Erasmus B.J. 1994. Bluetongue. *In* Infectious diseases of livestock with special reference to southern Africa (J.A.W. Coetzer, G.R. Thomson & R.C. Tustin, eds). Oxford University Press, Cape Town, 443-459.

