

A web based Geographical Information System network for vector-borne diseases surveillance

F. DALL'ACQUA - C. PALADINI - L. SAVINI - C. IPPOLITI - A. CONTE - R. MEISWINKEL - D. ZIPPO - P. CALISTRI

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

Summary

A web-based Geographic Information System (GIS) has been recently implemented for the surveillance of bluetongue a vector-borne animal disease transmitted by insects of the genus *Culicoides* (Diptera, Ceratopogonidae). This surveillance network was part of a one year long cooperation project involving several Balkan countries. A disease transmitted by flying insects, like BT, is a trans-boundary problem and cannot be prevented through individual national measures and animal trade control policy only. Since other vector-borne diseases are periodically detected in the Mediterranean Basin (such as West Nile Fever) or are emerging zoonoses endangering the Mediterranean area (such as Crimean-Congo hemorrhagic fever), the Italian Ministry of Foreign Affairs in collaboration with the Abruzzo Region decided to fund a further project both to strengthen the BT surveillance network, and to extend it to these two emerging and zoonotic diseases in Balkan and Eastern Mediterranean countries. The web site, with multi-user access, will be easily accessed by a generic Internet browser. The system is completely automatic and the user can enter, retrieve, analyse and exchange data and new information directly on-line. Furthermore, authorized customers can access directly the database and view, on real time, maps and tables with all the epidemiological details (i.e. outbreaks distribution). This continuous flow of information and data into the system, provides a clearer picture of the epidemiological trend and of the diseases risk factors and a common resource to facilitate decision-making and management in disease control at the international level.

Keywords:

Balkans, Bluetongue, Crimean-Congo hemorrhagic fever, *Culicoides*, Geographic information systems, Europe, Surveillance network, Websites, West Nile Fever.

Introduction

Bluetongue (BT) is an infectious, non-contagious, arthropod-borne disease transmitted by various species of biting midges of the genus *Culicoides* and affects domestic and wild ruminants. The causative agent of the disease is a virus of the genus *Orbivirus*, family *Reoviridae* (21). During the recent severe outbreaks of BT in the Mediterranean Basin, the BT virus (BTV) spread beyond its historical limits into the Balkan region. Bluetongue, is a trans-boundaries disease and individual national effort are not sufficient for effective surveillance and control. The primary impacts of BT is the cessation in livestock trade which can have severe economic and social consequences (14). Therefore, an integrated supranational approach is required to analyze both regional and global distribution of the infection as well as of the competent vectors. In this context, the use of Geographic Information Systems (GIS) enhances data analysis capabilities and facilitates the understanding of disease dynamics and spread. To deal with this issue, a collaborative programme was developed with the aim to assist all affected and at-risk Balkan states and adjoining countries in the management of BT, and to support the development of individual national surveillance systems (14).

A BT surveillance network was developed by the OIE-Collaborating Center for Veterinary Training, Epidemiology, Food Safety and Animal Welfare, Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise "G. Caporale", Italy (OIE CC-IZSA&M), in the framework of the project "Cooperation for implementing a surveillance network for bluetongue in the Balkanic area (East-BTNet)" in collaboration with the Veterinary Service and National Veterinary Institutes of: Albania, Bosnia-Herzegovina, Bulgaria, Croatia, Cyprus, the Former Yugoslavia Republic of Macedonia, Kosovo, Malta, Romania, Serbia and Montenegro, Slovenia and Turkey (14, 54).

This system is a web-based GIS, a tool for the rapid collection, analysis, interpretation and dissemination of large quantities of data generated by national/regional bluetongue monitoring programs. This common resource of information facilitates decision-making and management in disease control also at the international level. The principal objective of the project was to standardise measures for the harmonisation of this regional surveillance network. Moreover, the system was designed to give a clear regional picture of the distribution of BT, also using geographic information systems (GIS) technologies, and to provide a common source of data for further analyses and information exchange (14). Spatial and alphanumeric data on the disease are organised in a single relational geographic database. The system, with multi-user access, is equipped with a number of applications for the display of dynamic maps and data via the web (54).

In 2006, the Italian Ministry of Foreign Affairs in collaboration with the Abruzzo Region approved and funded a further project both to strengthen the BT surveillance network and to extend it to other vector borne diseases such as West Nile Fever (WNV) and Crimean-Congo hemorrhagic fever (CCHF), in the same areas. In respect of vector-borne zoonoses, WNV and CCHF are indeed emerging diseases in the Balkan and Eastern European area.

West Nile virus (WNV) is a Flavivirus closely related to Japanese encephalitis and St. Louis encephalitis viruses that is primarily maintained in nature by transmission cycles between mosquitoes and birds. Occasionally, WNV infects and causes disease in other vertebrates, including humans and horses (9). It was isolated in 1996 in Romania, with more than 500 human clinical cases and a case fatality rate approximately 10% (31, 40, 53, 59), in 1997 in Czech Republic with 5 human cases (29, 30), and in 1998 in Italy where clinical cases occurred only in horses (1). In the past, evidence of virus presence was notified in Albania in 1958 (4), Greece between 1970 and 1978 (1, 35), Bulgaria in 1978 (34), Hungary in the 70s (43, 44), Slovakia during the years 1970-73 (20, 38, 36, 37, 56, 24), Moldavia in the 70s (10, 11, 31) Ukraine in the 70s (61) and in 1985 (7, 60), Algeria in 1994 (28, 32, 51), Morocco in 1996 (47) and in 2003 (55), Tunisia in 1997 (28, 32, 51, 47, 58), and 2003 (62), Israel in 1999 and 2000 (47, 57), Russia in 1999 (47) and France in 1962 (26, 27), 2000 (46), 2003 (41, 15) and 2004 (39).

Crimean-Congo hemorrhagic fever (CCHF) is a tick-borne disease caused by the arbovirus Crimean-Congo hemorrhagic fever virus (CCHFV), which is a member of the Nairovirus genus (family Bunyaviridae). CCHF is an often fatal viral infection and it has the most extensive geographic

distribution of the medical important tick-borne viral diseases. Human beings become infected through tick bites, by crushing infected ticks, after contact with a patient with CCHF during the acute phase of infection, or by contact with blood or tissues from viraemic livestock (18).

Crimean-Congo hemorrhagic fever was first identified in the Balkans in 1954 (49). Since then, CCHF has occurred regularly in the Balkan region (19, 49), with the number of cases related to the number of ticks infected. By 2000, new outbreaks had been reported from Albania (48), United Nations Interim Administration Mission in Kosovo (UNMIK) with 69 human cases and six of them were fatal (16, 49), Bulgaria in 2002 with 56 cases (12 deaths) and in 2003 with 14 cases (2 deaths) (50). Between 2002 and 2005, 500 cases were reported to Turkish Ministry of Health and 26 of these died (3, 19, 33, 18). Nowadays CCHF virus is endemic in Bulgaria (50), in UNMIK (16, 49) and Albania (48).

Vector-borne diseases like BT and WNV cannot be prevented through animal trade control policy only because the insect vector is able to cross national boundaries. For instance, the Adriatic Sea is a natural barrier that divided Italy from the Balkan Region but it might not be efficacious to prevent the possible introduction of vector-borne diseases. Moreover, WNV and CCHF diseases are an emergent and serious problem in Public Health both for their ability to cause large epidemics (like for example the WNV in USA) and to rapidly spread following the routes of animal trade (i.e. CCHF). Consequently, it is of paramount importance to develop and implement trans-national and harmonized surveillance systems also for WNV and CCHF for allowing a continuous exchange of data produced by the epidemiological surveillance program in place in the several countries. This flow of information into the system will be essential to the production of diseases risk maps and will guarantee to have a clearer picture of the epidemiological trends.

The steps taken for implementing BT surveillance network at the Regional level and future plans for the expansion of the surveillance system at a larger scale and also for other vector-borne diseases are discussed.

Materials and methods

The establishment of a regional surveillance network for BT and the preparation of common standardised procedures at regional level require knowledge of the existing surveillance systems, skills and training needs, availability of diagnostic equipments and hardware/software for data management and epidemiological analysis. This background information was obtained with visits in loco and via a questionnaire to gain information on clinical, entomological and serological surveil-

lance and on the information system used. Standardised entomological and serological procedures were developed. For the former, a reference geographical unit of 400 km² was used, in which one blacklight trap for the capture of *Culicoides* would be operated weekly. For the latter, the diagnostic tests and kits to be used were recommended and different surveillance schemes suggested. An information system was implemented to compare and to combine the standardized entomological and serological data sets. The type of data needed to update the system was defined. The system comprises compulsory and optional fields.

A web-based surveillance network (www.east-bt.net.izs.it) was planned and implemented. The website is accessed simply via a generic internet browser and it is divided into different sections, as follows:

- one section on BT occurrence and BT (serological and entomological) data collection, data retrieval, and viewing of maps through the GIS application;
- five sections related to store and retrieve documents on BT technical, scientific, legislative aspects as well as training;
- one discussion forum section on BT;
- one section on useful links to other web resources.

The database on serological and entomological 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.

A series of training workshops on BT (epidemiology, serology, virology, biology and identification of *Culicoides*, the use of GIS, of automatic weather station and blacklight trap) were organised for the veterinary personnel of all countries. Moreover, the diagnostic equipment to perform entomological, virological and serological tests was purchased by the OIE CC-IZSA&M and delivered to some countries in accordance with a previous needs assessment.

Results

The needs assessment questionnaire revealed the BT surveillance activities in the twelve countries were not homogeneous and all countries expressed the need to strengthen their expertise in different aspects of BT. They participated in the national and international training courses on diagnostic activities (serological, virological and entomological), epidemiological surveillance, GIS and on ecological aspects.

The implemented website (www.east-bt.net.izs.it) is mainly a visualization system for the retrieval of BT technical, scientific, legislative and epidemiological information (by also querying the databa-

ses using GIS tools). Information is presented in map, tabular or text formats, depending on the type of data. Information is shared via dynamic interactive web pages (dhtml). Moreover, is available a discussion forum where ideas, questions and problems on BT are shared by users via a web-based message system.

A web-based GIS network was developed and implemented to provide veterinary services with an efficient tool for the management and analysis of data and the dissemination of information relevant to BT. The interactive thematic maps together with standard ArcIMS tools (zoom in, zoom out, pan, buffering) and query functions (hyperlinks, identifier, query) permits to personalize map views.

Furthermore, the GIS section is used to collect epidemiological data on:

- BTV distribution (yearly or other defined time period – data aggregated by administrative unit/s detailed data for each geo-referred outbreak);
- serological surveillance activities (monthly or other defined time period – aggregated by administrative unit/s);
- entomological surveillance data (detailed data for each *Culicoides* catch).

Real-time dynamic maps can be generated in response to new data entry on-line. Spatial and alphanumeric data on the disease were organised in a single relational geographic database. The system is equipped with a number of applications for the display of dynamic maps and data via the web, with multi-user access for simultaneous queries from additional users.

The functions mentioned above are described in greater details in Dall'Acqua et al (14) and in Savini et al (54).

Discussion

The development of web-based surveillance network that allows a continuous flow of epidemiological information, is yet to be used more widely in the veterinary field (8, 12, 17, 22, 23, 42), despite its already extensive application in existing worldwide human health domains (1, 6, 13, 25, 45, 52).

The Balkan and Eastern Mediterranean countries through the project "Cooperation for implementing a surveillance network for bluetongue" (East-BTNet) have experienced a novel approach in the surveillance activities of BT; in fact, for the first time the epidemiological information produced by the programs in place in each involved country flew into a single and harmonized trans-national system.

The system was designed to give a clear Regional picture of the distribution of BT, and to provide a common source of data enabling national veterinary authorities to cope with a BT incursion. In

fact, by regularly testing of large numbers of livestock the gathered information is: early detection of BTV circulation, identification of BTV serotypes involved, evaluation of the sanitary status of susceptible animal populations and identification of seasonally free areas.

The system was also intended to facilitate information exchange taking advantage of the geographic information systems (GIS) technologies. Indeed, real-time dynamic maps can be generated via the web in response to shifts in the distribution of the virus (8). Furthermore, the web-based instrument developed, not only provides the veterinary services of participating countries with a useful tool for managing, analysing and sharing epidemiological data, but also contributes for the harmonisation of the surveillance plans through the standardisation of the data collected by the information systems (14).

The established bluetongue web-based system proved to be very successful at international level and laid the basis for the extension and implementation of a surveillance network for vector-borne diseases of veterinary (BT) and public health concern (WNF and CCHF) across a larger geographic area (Europe and Mediterranean countries). Certainly, the system can be easily tailored for other diseases. This further step will permit to have a clearer overview and understanding of the epidemiology of BT, WNF and CCHF at a greater scale. Moreover, it will allow to continue to build valuable historical databases for future risk analysis studies also for other emerging diseases (i.e. African horse sickness, Epizootic Haemorrhagic disease).

Acknowledgements

Sincere thanks are extended to the personnel of the Institute for the Protection and the Security of the Citizen, the European Commission Joint Research Centre (IPSC-JRC), Italy, for their collaborative support and technical assistance during the training activities. From the IZSA&M we thank the personnel 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. Antoniadis A., Alexiou-Daniel S., Malissiovas N., Doutsos J., Polyzoni T., LeDuc J.W., Peters C.J. & Saviolakis G. 1990. Seroepidemiological survey for antibodies to arboviruses in Greece. *Arch Virol*, 1: 277-285.
2. Autorino G.L, Battisti A., Deubel V., Ferrari G., Forletta R, Giovannini A., Lelli R., Murri S. & Scicluna M.T. 2002. *Emerg Infect Dis*, 8: 1372-1378.
3. Bakir M., Ugurlu M., Dokuzoguz B., Bodur H., Tasyaran M.A. & Vahaboglu H. 2005. Crimean-Congo haemorrhagic fever outbreak in Middle Anatolia: a multicentre study of clinical features and outcome measures. *J Med Microbiol*, 54: 385-389.
4. Bárdos V., Adamcová J., Dedei S., Gjini N., Rosicky B. & Imková A. 1959. Neutralizing antibodies against some neurotropic viruses determined in human sera in Albania. *J Hyg Epidemiol Microbiol Immunol*, 3: 277-282.
5. 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.
6. 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 31 January 2007).
7. Buletsa B.A., Turak J.A., Korol M.J., Ignatovich I.I. & Vitvitskiy A.A. 1989. Neurological manifestations of West Nile fever in the Transcarpathian region, Ukrainian SSR (in Russian). *Zhurnal Nevrologii Psikiatrii*, 89: 29-30.
8. 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.
9. Castillo-Olivares J. & Wood J. 2004. West Nile virus infection of horses. *Vet Res*, 35: 467-483.
10. Chumakov M.P., Bashkirtsev V.N., Golger E.I., Dzagurova T.K., Zavodova T.I., Konovalov Y.N., et al. 1974. Isolation and identification of Crimean hemorrhagic fever and West Nile fever viruses from ticks collected in Moldavia (in Russian). *Medicinskaya Virusologia*, 22: 45-49.
11. Chumakov M.P., Spasskiy A.A., Uspenskaya I.G., Tikhon E.I., Zaitsev N.A., Konovalov Y.N., et al. 1981. Virological, serological, zoological, and ecological investigations of natural foci of arbovirus infections in Moldavian SSR (in Russian). *Abstr Conf "Viruses and virus infections of humans."* Moskva, 101.
12. 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. - Off. Int. Epizoot.*, 24 (3), 857-868.
13. Croner C.M. 2003. Public health, GIS and the Internet. *Ann Rev Publ Health*, 24, 57-82.
14. Dall'Acqua F., Paladini C., Meiswinkel R., Savini L. & Calistri P. 2006. Description and implementation of a

- surveillance network for bluetongue in the Balkans and in adjoining areas of south-eastern Europe. *Vet Ital*, 42 (2), 103–118.
15. Del Giudice P, Schuffenecker I, Vandenbos F, Counillon E, Zeller H. 2004. Human West Nile virus, France [letter]. *Emerging Infect. Dis.*, 10: 1885–1886.
 16. Drosten C., Minnak D., Emmerich P., Schmitz H. & Reinicke T. 2002. Crimean–Congo hemorrhagic fever in Kosovo. *J. Clin. Microbiol.*, 40: 1122–1123.
 17. Egbert M. 2004. Web-based disease tracking: a West Nile virus example. (gis.esri.com/library/userconf/proc04/docs/pap1131.pdf accessed on 31 January 2007).
 18. Ergönül Ö. 2006. Crimean–Congo haemorrhagic fever. *Lancet Infect Dis*, 6: 203–214.
 19. Ergönül Ö., Çelikbafl A., Dokuzoguz B., Eren fi., Baykam N. & Esener H. 2004. Characteristics of Patients with Crimean–Congo Hemorrhagic Fever in a Recent Outbreak in Turkey and Impact of Oral Ribavirin Therapy. *Clin. Infect. Dis.*, 39: 284–287.
 20. Ernek E., Kozuch O., Nosek J., Teplan J. & Folk C. 1977. Arboviruses in birds captured in Slovakia. *J Hyg Epidemiol Microbiol Immunol*, 21: 353–359.
 21. Gibbs E.P.J. & Greiner E.C. 1994. The epidemiology of bluetongue. *Comp Immunol Microbiol Infect Dis*, 17: 207–220.
 22. 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.
 23. 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 31 January 2007).
 24. Gresíková M. & Sekeyová M. 1967. Haemagglutination-inhibiting antibodies against arboviruses in the population of Slovakia. *J Hyg Epidemiol Microbiol Immunol*, 11: 278–285.
 25. 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. (<http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1291387> accessed on 31 January 2007).
 26. Hannoun C., Panthier R. & Corniou B. 1969. Epidemiology of West Nile infections in the South of France. In: Bárdos V, editor. *Arboviruses of the California complex and the Bunya–mvera group*. Bratislava: Publ House SAS, 379–387.
 27. Hannoun C., Panthier R., Mouchet J. & Eouzan J.P. 1964. Isolement en France du virus West Nile à partir de malades et du vecteur *Culex molestus* Ficalbi. *Compte Rendu de l'Académie des Sciences*, D259: 4170–4172.
 28. Hubálek Z. & Halouzka J. 1996. Arthropod-borne viruses of vertebrates in Europe. *Acta Scientiarum Naturalium Brno*, 30 (4–5): 1–95.
 29. Hubálek Z., Halouzka J., Juricová Z. & Sebesta O. 1998. First isolation of mosquito-borne West Nile virus in the Czech Republic. *Acta Virol*, 42:119–120.
 30. Hubálek Z., Halouzka J. & Juricová Z. 1999. West Nile fever in Czechland. *Emerg Infect Dis*, 5 (5): 594–595.
 31. Hubálek Z. & Halouzka J. 1999. West Nile Fever—a Reemerging Mosquito-Borne Viral Disease in Europe. *Emerg Infect Dis*, 5 (5): 643–650.
 32. Karabatsos N., editor. 1985. *International catalogue of arboviruses, including certain other viruses of vertebrates*. 3rd ed., and Supplements 1986–98. San Antonio: American Society of Tropical Medicine and Hygiene.
 33. Karti S.S., Odabasi Z., Korten V., et al. 2004. Crimean–Congo hemorrhagic fever in Turkey. *Emerg Infect Dis*, 19: 1379–1384.
 34. Katsarov G., Vasilenko S., Vargin V., Butenko S. & Tkachenko E. 1980. Serological studies on the distribution of some arboviruses in Bulgaria. *Problems of Infectious and Parasitic Diseases*, 8: 32–35.
 35. Koptopoulos G. & Papadopoulos O. 1980. A serological survey for tick-borne encephalitis and West Nile viruses in Greece. *Zentralblatt für Bakteriologie*, 9: 185–188.
 36. Kozuch O., Nosek J. & Labuda M. 1980. Arboviruses occurring in western Slovakia and their hosts. In: Labuda M, Calisher CH, editors. *New aspects in ecology of arboviruses*. Bratislava: Inst Virol SAS, 323–333.
 37. Kozuch O., Nosek J., Gresíková M. & Ernek E. 1976. Surveillance on mosquito-borne natural focus in Záhorská lowland. In: Sixl W, Troger H, editors. *Naturherde von Infektionskrankheiten in Zentraleuropa*. Graz: Hyg Inst Univ, 115–118.
 38. Labuda M., Kozuch O. & Gresíková M. 1974. Isolation of West Nile virus from *Aedes cantans* mosquitoes in west Slovakia. *Acta Virol*, 18: 429–33.
 39. Languille J., Zientara S., Zeller H., Hendrikx P., Armengaud A., & Hars J. 2004. Bilan de la surveillance West Nile en France. (http://www.agriculture.gouv.fr/spip/IMG/pdf/article_wn_2004_5.pdf accessed on 31 January 2007).
 40. Le Guenno B., Bougermouh A., Azzam T. & Bouakaz R. 1996. West Nile: A deadly virus? *Lancet*, 348:1315.
 41. Mailles A., Dellamonica P., Zeller H., Durand J.P., Zientara S., Goffette R, et al. 2003. Human and equine infections in France, August–September 2003. *Eurosurveillance Weekly*. 7:10/23/2003. (<http://www.eurosurveillance.org/ew/2003/031023.asp> accessed on 31 January 2007).
 42. 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 31 January 2007).
 43. Molnár E., Gresíková M., Kubászová T., Kubinyi L. & Szabó J.B. 1973. Arboviruses in Hungary. *J Hyg Epidemiol Microbiol Immunol*, 17: 1–10.
 44. Molnár E., Gulyas M.S., Kubinyi L., Nosek J., Kozuch O., Ernek E., et al. 1976. Studies on the occurrence of tick-borne encephalitis in Hungary. *Acta Veterinaria Academiae Scientiarum Hungaricae*, 26: 419–438.
 45. Moreno–Sanchez R., Hayden M., Janes C. & Anderson G. 2006. A web-based multimedia spatial information system to document *Aedes aegypti* breeding sites and dengue fever risk along the US–Mexico border. *Health Place* 12 (4), 715–727. (doi:10.1016/j.healthplace.2005.10.001 accessed on 31 January 2007).

46. Murgue B., Murri S., Zientara S., Durand B., Durand J.P. & Zeller H. 2001. West Nile outbreak in horses in Southern France, 2000: the return after 35 years. *Emerg Infect Dis*, 7: 692–696.
47. Murgue B., Zeller H. & Deubel V. 2001. West Nile in the Mediterranean basin: 1950–2000. *Ann NY Acad Sci*, 951: 117–126.
48. Papa A., Bino S., Llagami A., et al. 2002. Crimean–Congo hemorrhagic fever in Albania, 2001. *Eur J Clin Microbiol Infect Dis*, 21: 603–606.
49. Papa A., Bozovi B., Pavlidou V., Papadimitriou E., Pelemis M. & Antoniadis A. 2002. Genetic Detection and Isolation of Crimean–Congo hemorrhagic fever virus, Kosovo, Yugoslavia. *Emerg Infect Dis*, 8 (8): 852–854.
50. Papa A., Christova I., Papadimitriou E. & Antoniadis A. 2004. Crimean–Congo hemorrhagic fever in Bulgaria. *Emerg Infect Dis*, 10: 1465–1467.
51. Peiris J.S.M. & Amerasinghe F.P. 1994. West Nile fever. In: Beran GW, Steele JH, editors. *Handbook of zoonoses. Section B: Viral*. 2nd ed. Boca Raton (FL): CRC Press, 139–148.
52. 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 31 January 2007).
53. Savage H.M., Ceianu C., Nicolescu G., Karabatsos N., Lanciotti R., Vladimirescu A., Laiv L., Ungureanu A., Romanca C. & Tsai T.F. 1999. Entomologic and avian investigations of an epidemic of West Nile fever in Romania, 1996, with serologic and molecular characterization of a virus isolate from mosquitoes. *Am J Trop Med Hyg*, 61 (4): 600–611.
54. 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), 201–207.
55. Schuffenecker I., Peyrefitte C.N., Mohammed el Harrak, Murri S., Leblond A. & Zeller H.G. 2005. West Nile Virus in Morocco, 2003. *Emerg Infect Dis*, 11 (2), 306–309.
56. Sekeyová M., Gresíková M. & Kozuch O. 1976. Haemagglutination–inhibition antibodies to some arboviruses in sera of pigeons trapped in Bratislava. In: Sixl W, Troger H, editors. *Naturherde von Infektionskrankheiten in Zentraleuropa*. Graz: Hyg Inst Univ, 187–189.
57. Steinman A., Banet C., Sutton G.A., Yadin H., Hadar S. & Brill A. 2002. Clinical signs of West Nile virus encephalomyelitis in horses during the outbreak in Israel in 2000. *Vet Rec.*, 151: 47–49.
58. Triki H., Murri S., Le Guenno B., Bahri O., Hili K., Sidhom M. & Dellagi K. 2001. West Nile viral meningoencephalitis in Tunisia. *Med. Trop. (Madr.)*, 61: 487–490.
59. Tsai T.F., Popovici F., Cernescu C., Campbell G.L. & Nedelcu N.I. 1998. West Nile encephalitis epidemic in southeastern Romania. *Lancet*, 352: 767–771.
60. Vinograd I.A., Beletskaya G.V., Chumachenko S.S., Omelchenko G.A., Lozinski I.N., Yartys O.S., et al. 1989. Ecological aspects of arbovirus studies in the Ukrainian SSR (in Russian). In: Lvov DK, Gaidamovich SY, editors. *Ecology of viruses and diagnostics of arbovirus infections*. Moscow: Acad Med Sci USSR, 21–27.
61. Vinograd I.A. & Obukhova V.R. 1975. Isolation of arboviruses from birds in western Ukraine (in Russian). *Sbornik Trudov Instituta Virusologii (Moskva)*, 3: 84–7.
62. Zeller H.G. & Schuffenecker I. 2004. West Nile virus: an overview of its spread in Europe and the Mediterranean basin in contrast to its spread in the Americas. *Eur J Clin Microbiol Infect Dis.*, 23: 147–156.