Vet. Ital., **40** (3), 226-231

Entomological surveillance of bluetongue in France in 2002

T. Baldet[(1)], J.-C. Delécolle[(2)], B. Mathieu[(3)], S. de La Rocque[(1)] & F. Roger[(1)]

(1) CIRAD-EMVT, TA 30 E, Campus International de Baillarguet, 34 398 Montpellier, France
(2) Musée Zoologique de l'Université Louis Pasteur et de la Ville de Strasbourg (MZS), 29 bd de la Victoire, 67000 Strasbourg, France
(3) Entente interdépartementale pour la démoustication du littoral méditerranéen (EID-Méditerranée), 165 avenue Paul Rimbaud, 34184 Montpellier Cedex 4, France

Summary

Bluetongue (BT) is an arboviral disease that appeared in the Mediterranean in 1998. In France, the principal vector, *Culicoides imicola*, was detected for the first time in Corsica in October 2000, a few weeks before outbreaks of BT virus serotype 2 (BTV-2). Entomological surveillance was implemented in Corsica and on mainland France in 2002. In Corsica, the aim was to study the population dynamics of *C. imicola* and other potential vectors. On the coastal mainland, the objective was to survey the introduction of *C. imicola*. One-night catches per site were performed every three weeks at 12 sites on Corsica and every month at 19 sites on the mainland. In Corsica, 84 790 *Culicoides* belonging to 50 species were collected over 180 nights. *C. imicola* accounted for 18.3% of the total captured. On the mainland, 16 197 *Culicoides* (44 species over 109 nights) were collected, none of which were *C. imicola*. The geographic and seasonal distribution of *C. imicola* and other species of interest are discussed in relation with their bio-ecology and environment. These datasets are essential for a better understanding of the epidemiology of BT, and to create and validate predictive models based on remote sensing in order to identify areas at risk for BT.

Keywords

Bluetongue – Corsica – *Culicoides imicola* – *Culicoides newsteadi* – *Culicoides obsoletus* – *Culicoides pulicaris* – France – Surveillance.

Introduction

Bluetongue (BT) is an infectious arthropod-borne viral disease that affects ruminants, mainly sheep. BT virus (BTV) is transmitted between its vertebrate hosts by certain species of *Culicoides* biting midges (Diptera: Ceratopogonidae). BT occurs pantropically between 44°N and 35°S depending mainly upon the distribution and seasonal presence of *Culicoides* midges. More than 1 200 *Culicoides* species have been identified in the world (1), but only 17 have been connected with BTV transmission. The major vector species are *C. imicola* and *C. bolitinos* in Africa; *C. imicola* and *C. fulvus* in Asia; *C. brevitarsis* and *C. fulvus* in Australia; *C. sonorensis* in North America, *C. insignis* and *C. pusillus* in South and Central America (9). Worldwide, BTV causes losses of approximately US$3 billion each year (13). Indeed, BT is considered to be of such major international concern that it has been given 'List A' status by the Office International des Épizooties.

Since its appearance in the Mediterranean Basin in 1998, BT disease has had a devastating effect on the sheep industry, resulting in the loss of over 300 000 sheep until 2001 (10). The spread of BT into areas of Europe never previously affected, is linked to the northern spread of its main Afro-Asian vector *C. imicola* (2) by air streams. *C. imicola sensu lato* is a complex of at least 10 sibling species but, at present, only *C. imicola sensu stricto* is present in Europe (8).

In the eastern Mediterranean Basin, BTV outbreaks have occurred in regions of the Balkans up to 44°30´N, and in places where *C. imicola* has not been been detected during previous insect surveys (10). Recently, BTV-2 has been isolated in one or more species of the *C. obsoletus* complex on mainland Italy (15) and *C. pulicaris* on the island of Sicily (5), suggesting that BTV could be transmitted by these Palaearctic *Culicoides* species associated with livestock. As these species or species complexes are widespread and abundant in the Mediterranean and across most of northern Europe, it would be of

interest to confirm whether they are able to transmit BTV in the field.

In France, the main vector, *C. imicola*, was detected for the first time on the island of Corsica in October 2000 (7). Subsequently, important outbreaks caused by BTV-2 occurred in autumn 2000 and 2001 (18, 19, 20). In combination with the vaccination campaigns conducted between 2001 and 2003, an entomological surveillance network was established in 2002, as follows:

a) in Corsica, to study the population dynamics of *C. imicola* and other potential vector species (*C. obsoletus* and *C. pulicaris*)

b) on the coastal mainland of France, to survey the introduction of *C. imicola* and study the population dynamics of other *Culicoides* species.

Materials and methods

Twelve representative sites were selected in Corsica (farms affected by BTV-2 outbreaks in 2000 and/or 2001) and 19 farms at risk on the coastal mainland at intervals of 50 km (Fig. 1). One-night catches per site using UV-light traps (7) were performed every three weeks in Corsica and every month on the mainland.

Figure 1
Location of sites surveyed for *Culicoides* in France, 2002

Traps were located outdoors, within 25 m of livestock premises and suspended from the walls of buildings 1.5-2 m above ground level. Traps were set 1 h before sunset and collection was made at about 8 am the next morning. The insects were transported to the laboratory in a water-filled beaker and then covered and preserved in 90% ethanol. Ceratopogonidae were first separated from all other insects. *Culicoides* were identified based on wing patterns, and subsequently confirmed by mounting specimens on microscope slides (6, 16).

Results

To facilitate rapid access to entomological surveillance data, results are available on the website of the *Centre de coopération internationale en recherche agronomique pour le développement* (CIRAD) at blue-tongue.cirad.fr/resultats_entomologiques/Consultation.php.

Corsica

From February to December 2002, 84 790 *Culicoides* belonging to at least 50 species were collected in a total of 180 night catches. *C. imicola* accounted for 18.3% of the specimens captured, with a maximum and average catch size of 4 814 and 86, respectively (Table I). *C. imicola* was predominant at two sites located in the extreme south of the island (Porto-Vecchio and Figari) and less prevalent in Moltifao, the only site located inland at an altitude of 250 m (Fig. 2). Adult densities reached a peak in September-October, at the end of the summer (Fig. 3). The other most abundant and widespread species were *C. newsteadi* (36.8%, 4 018 and 174), *C. scoticus* (18%, 4 016 and 85), *C. obsoletus* (9.2%, 1 912 and 43), *C. circumscriptus* (4.2%, 507 and 20) and *C. pulicaris* (3.8%, 626 and 18). The 43 remaining species accounted for less than 2% of the total.

C. newsteadi, a halophilic species, is predominant in the western and southern coastal plains and is rare on the eastern and northern rocky coasts. *C. pulicaris*, a species found more often in low and midland

Table I
Adults of *Culicoides* collected in Corsica, February-December 2002
(12 sites/11 months/180 night catches)

Culicoides species	Number collected (%)	Size of maximum catch	Size of average catch
C. newsteadi	31 224 (36.8)	4 018	173.5
C. imicola	**15 530 (18.3)**	**4 814**	**86.3**
C. scoticus	15 280 (18.0)	4 016	84.9
C. obsoletus	7 762 (9.2)	1 912	43.1
C. circumscriptus	3 571 (4.2)	507	19.8
C. pulicaris	3 229 (3.8)	626	17.9
C. griseidorsum	1 558 (1.8)	802	8.7
C. subfagineus	1 141 (1.3)	433	6.3
C. lupicaris	1 140 (1.3)	330	6.3
Culicoides spp. (40 species)	4 355 (5.1)	–	24.2
Total *Culicoides* (50 species)	84 790 (100)	–	471.1

* The 40 remaining species accounted for less than 2% of the total

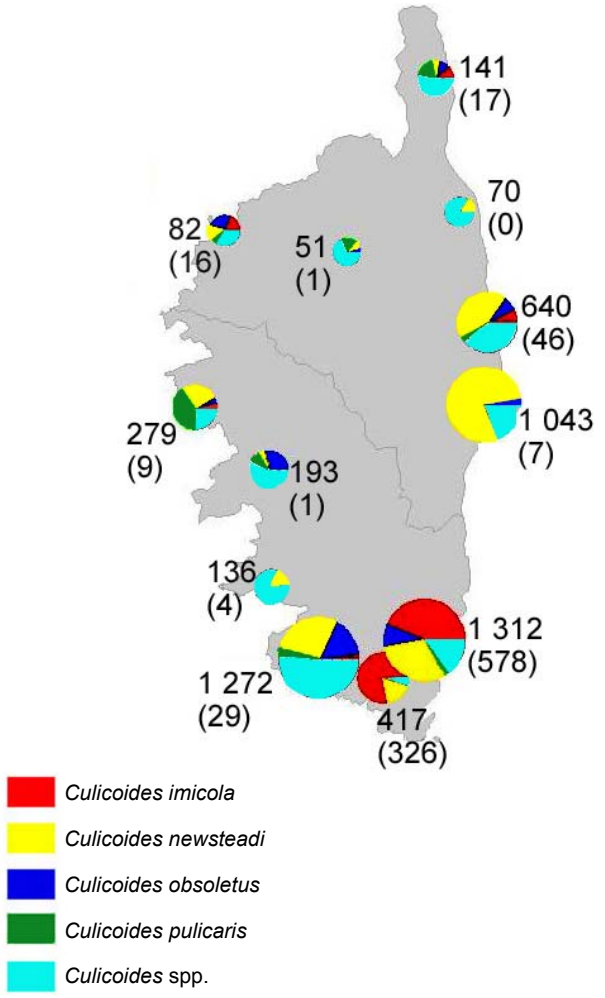

Figure 2
Spatial distribution of *Culicoides* collected in Corsica, 2002
(12 sites/11 months/180 night catches)

areas, predominated on these rocky coasts and in inland areas. For *C. obsoletus* and *C. pulicaris*, the seasonal dynamics of adult density show a bimodal pattern with two distinct peaks: one in spring and the other in autumn. During the summer, especially August, the elevated temperatures and weak hygrometry could be unfavourable to the larval development and/or adult active flight of these European species.

Mainland France

From April to November 2002, 16 197 *Culicoides* belonging to 44 species were collected in a total of 109 night catches. No specimens of *C. imicola* were found (Table II). The more abundant and widespread species were *C. newsteadi* (73.5%, 3 655 and 109), *C. obsoletus* (8%, 201 and 12), *C. scoticus* (5.4%, 417 and 8), *C. circumscriptus* (3.2%, 177 and 5) and *C. griseidorsum* (2.7%, 337 and 4). The remaining 39 species accounted for less than 2% of the total. Results are similar to those observed in Corsica but with less adults for each species. As in Corsica, *C. newsteadi* is predominant along the eastern coastal plains backed by marshland (from the Camargue, Rhône delta, to the Spanish border). *C. pulicaris* is more abundant on the western rocky coast (from the Rhône delta to the foothills of the Alps along the Italian border) and along the Spanish border at the foothills of the Pyrenees (Fig. 4). Similar to the findings in Corsica, a bimodal pattern of seasonal adult dynamics for *C. obsoletus* and *C. pulicaris* was observed with two peaks: one in spring and the other in autumn (Fig. 5).

Table II
Adults of *Culicoides* captured on the coastal mainland France, April-November 2002
(19 sites/8 months/109 night catches)
No specimens of *C. imicola* were found

Culicoides species	Number collected	Size of maximum catch	Size of average catch
C. newsteadi	11 898 (73.5)	3 655	109.2
C. obsoletus	1 290 (8.0)	201	11.8
C. scoticus	877 (5.4)	417	8.0
C. circumscriptus	526 (3.2)	177	4.8
C. griseidorsum	430 (2.7)	337	3.9
C. pulicaris	188 (1.2)	31	1.7
C. lupicaris	178 (1.1)	58	1.6
C. submaritimus	173 (1.1)	82	1.6
Culicoides spp. (36 species)*	637 (3.9)	–	5.8
Total *Culicoides* (44 species)	**16 197 (100)**	–	148.6

* The 36 remaining species accounted for less than 2% of the total

Discussion

During this entomological surveillance programme, *C. imicola* proved to be widely represented in Corsica. Its north/south gradient is likely to be the result of recent colonisation from Sardinia. Nevertheless, the relative abundance of *C. imicola* in the north (Balagne, Cap) compared to higher areas inland and to the west coast, suggests that several factors (climate, soil, topography, host presence) specific to each area play a crucial role in its local establishment and development. In general, in the Mediterranean region, *C. imicola* is restricted to plain coastal habitats up to an altitude of 800 m (12). Adult densities generally reach a peak in late summer and early autumn. These findings correlate with BT epidemiology in the temperate regions of the Mediterranean (10). The presence at most sites of *C. imicola* for eight months, from May to December, confirms that *C. imicola* over-wintered and is now permanently established in Corsica with several generations of adults during the active season. Thus, despite the fact that no specimens were found on

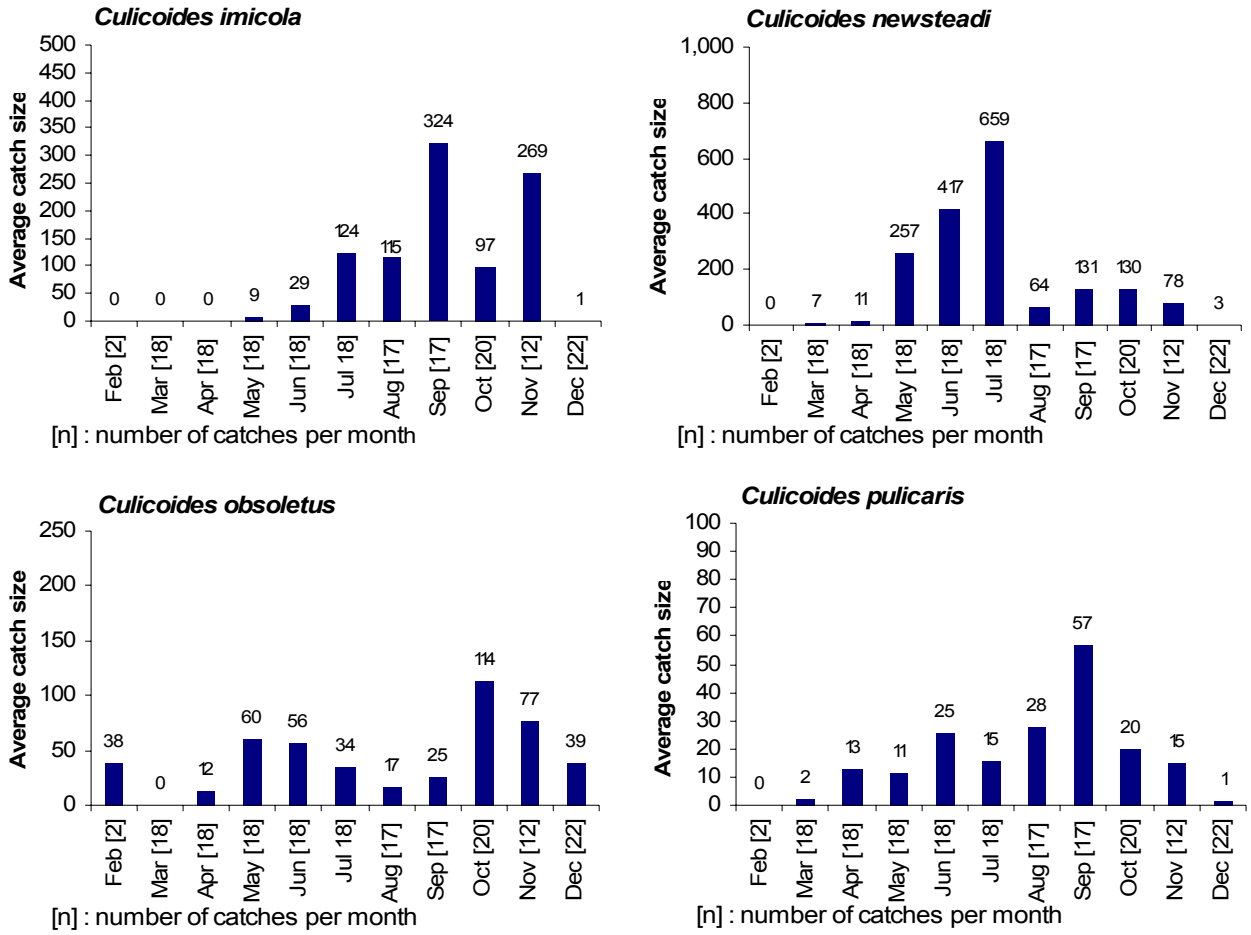

Figure 3
Seasonal distribution of *Culicoides imicola*, *C. newsteadi*, *C. obsoletus* and *C. pulicaris* in Corsica, 2002
NB: scales differ, depending on species

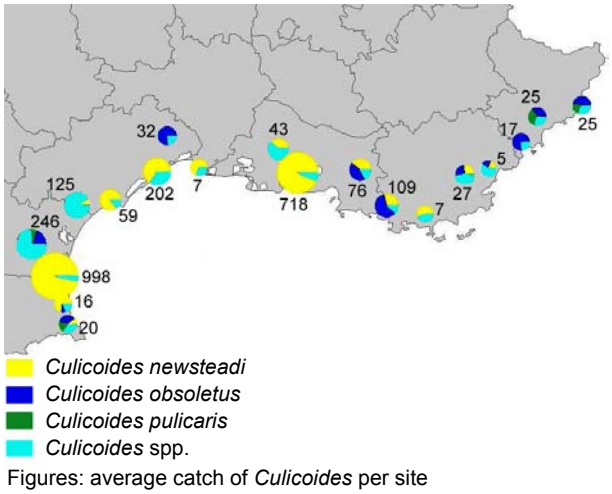

Figure 4
Spatial distribution of *Culicoides* collected on mainland France, 2002
(19 sites/8 months/109 night catches)

mainland France in 2002, the risk of invasion through air streams does exist.

Other species of interest that are widely distributed in Corsica are found in lower densities on mainland France. Spatial distribution is linked to specific bio-ecology, such as humid coastal lowlands for *C. newsteadi* and hilly rocky areas for *C. pulicaris*. Peak catches occurred in the spring and autumn; for *C. obsoletus* and *C. pulicaris* densities were higher in the autumn, and for *C. newsteadi* in the early summer. These spatial and seasonal patterns are similar to those observed in other countries of the Mediterranean Basin (3, 4, 11, 14).

C. obsoletus, the potential vector of BT in Europe, is close to *C. imicola* in terms of systematics (both belong to the subgenus *Avaritia*) and bio-ecology (both are commonly found in livestock-rearing environments). The abrupt decrease of *C. obsoletus* in summer may be due to the hot and dry conditions that would, in turn, favour the development of *C. imicola*, a tropical species more adapted to this kind of environment. Global warming could facilitate the colonisation of northern territories by *C. imicola*. Models based on an increase of 2°C in temperature showed that most of southern Europe and mainland France were susceptible to colonisation by *C. imicola* (17).

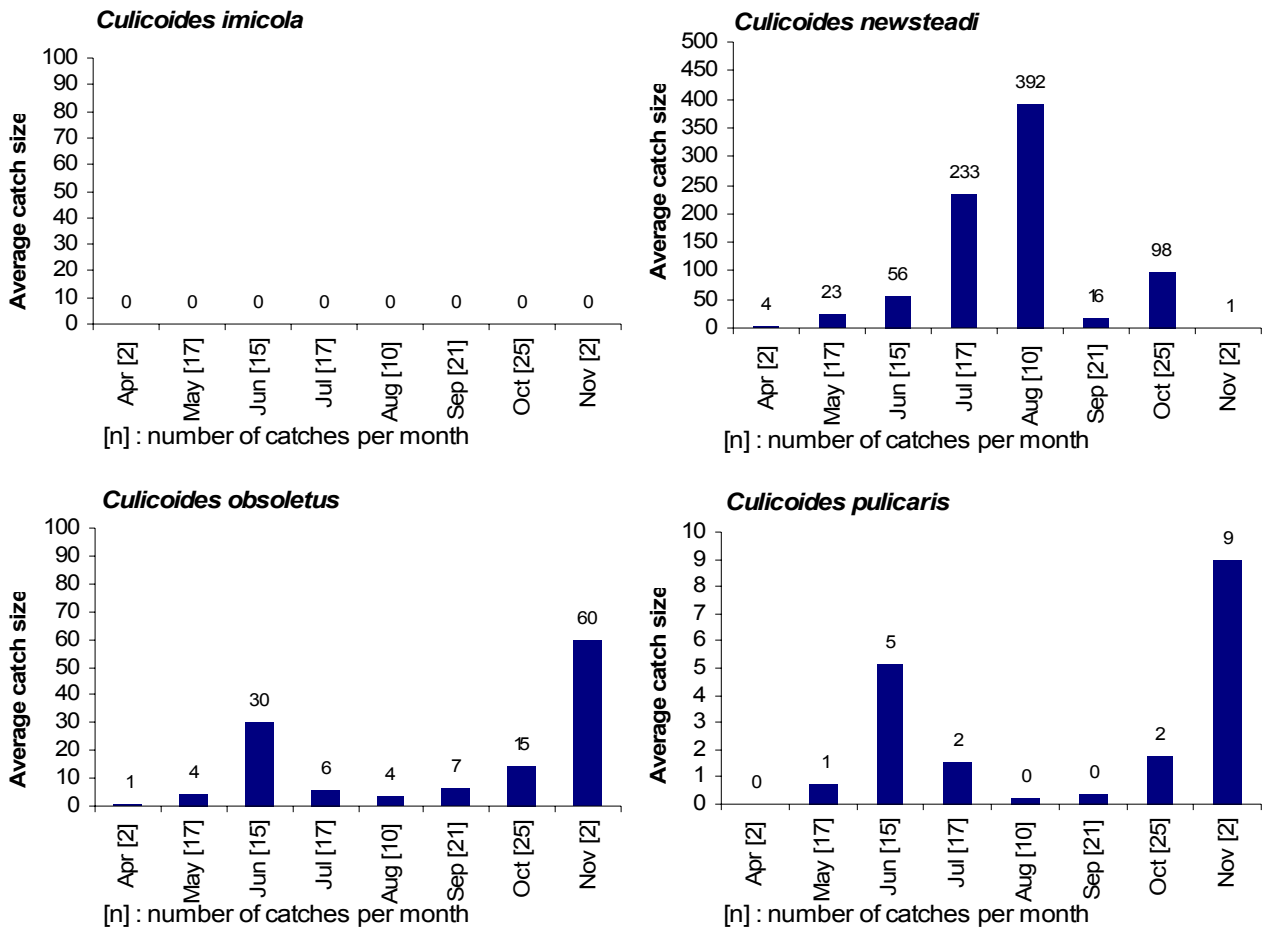

Figure 5
Seasonal distribution of *Culicoides imicola*, *C. newsteadi*, *C. obsoletus* and *C. pulicaris* on mainland France, 2002
NB: scales differ, depending on species

Entomological surveillance of BT in France was pursued after 2002. This long-term follow-up appears essential to ensure a better understanding of the epidemiology of BT, and the creation of models based on environmental and bio-ecology patterns that might help predict and identify areas at risk to introduction of the disease.

Acknowledgements

This work was funded by National Food Directorate, France (*Direction générale de l'Alimentation*)/French Ministry of Agriculture and conducted jointly by the CIRAD-EMVT, the Université Louis Pasteur de Strasbourg, Interdepartmental group for mosquito control from the Mediterranean coast (*Entente interdépartementale pour la démoustication du littoral méditerranéen* (EID-Méditerranée), Departmental Directorate of Veterinary Services, France (*Direction départementale des services veterinaires*) (DDSV) Haute-Corse and DDSV Corse du Sud.

References

1. Borkent A. & Wirth W.W. (1997). – World species of biting midges (*Diptera: Ceratopogonidae*). *Bull. Am. Mus. Nat. Hist.*, **233**, 257 pp.
2. Braverman Y. & Chechik F. (1996). – Air streams and the introduction of animal diseases borne on *Culicoides* (Diptera: Ceratopogonidae) into Israel. *Rev. Sci. Tech. Off. Int. Épiz.*, **15**, 1037-1052.
3. Calistri P., Goffredo M., Caporale V. & Meiswinkel R. (2003). – The distribution of *Culicoides imicola* in Italy: application and evaluation of current Mediterranean models based on climate. *J. Vet. Med.*, **50**, 132-138.
4. Capela R., Purse B.V., Pena I., Wittmann E.J., Margarita Y., Capela M., Romao L., Mellor P.S. & Baylis M. (2003). – Spatial distribution of *Culicoides* species in Portugal in relation to the transmission of African horse sickness and bluetongue viruses. *Med. Vet. Entomol.*, **17**, 165-177.
5. 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**, 71-74.

6. Delécolle J.-C. (1985). – Nouvelle contribution à l'étude systematique et iconographique des espèces du genre *Culicoide*s (Diptera: Ceratopogonidae) du nord-est de la France. Thesis, Université Louis Pasteur de Strasbourg, UER Sciences, Vie et Terre, 238 pp.

7. Delécolle J.-C. & de La Rocque S. (2002). – Contribution à l'étude des *Culicoides* de Corse. Liste des espèces recensées en 2000/2001 et redescription du principal vecteur de la fièvre catarrhale ovine *C. imicola* Kieffer, 1913 (Diptera: Ceratopogonidae). *Bull. Soc. Entomol. Fr.*, **107**, 371-379.

8. Linton Y.M., Mordue Luntz A.J., Cruickshank R.H., Meiswinkel R., Mellor P.S. & Dallas J.F. (2002). – Phylogenetic analysis of the mitochondrial cytochrome oxidase subunit I gene of five species of the *Culicoides imicola* species complex. *Med. Vet. Entomol.*, **16**, 139-146.

9. Mellor P.S., Boorman J. & Baylis M. (2000). – *Culicoides* biting midges: their role as arbovirus vectors. *Ann. Rev. Entomol.*, **45**, 307-340.

10. Mellor P.S. & Wittmann E.J. (2002). – Bluetongue virus in the Mediterranean Basin 1998-2001. *Vet. J.*, **164**, 20-37.

11. Miranda M.A., Borras D., Rincon C. & Alemany A. (2003). – Presence in the Balearic islands (Spain) of the midges *Culicoides imicola* and *Culicoides obsoletus* group. *Med. Vet. Entomol.*, **17** (1), 52-54.

12. Rawlings P., Pro M.J., Pena I., Ortega M.D. & Capela R. (1997). – Spatial and seasonal distribution of *Culicoides imicola* in Iberia in relation to the transmission of African horse sickness virus. *Med. Vet. Entomol.*, **11** (1), 49-57.

13. Tabachnick W.J., Robertson M.A. & Murphy K.E. (1996). – *Culicoides variipennis* and bluetongue disease. *Ann. NY Acad. Sci.*, **791**, 219-226.

14. Sarto i Monteys V. & Saiz-Ardanaz M. (2003). – *Culicoides* midges in Catalonia (Spain), with special reference to likely bluetongue virus vectors. *Med. Vet. Entomol.*, **17**, 288-293.

15. Savini G., Goffredo M., Monaco F., de Santis P. & Meiswinkel R. (2003). – Transmission of bluetongue virus in Italy. *Vet. Rec.*, **152**, 119.

16. Wirth W.W. & Marston N. (1968). – A method for mounting small insects on microscope slides in Canada balsam. *Ann. Entomol. Soc. Am.*, **61**, 783-784.

17. Wittmann E.J., Mellor P.S. & Baylis M. (2001). – Using climate data to map the potential distribution of *Culicoides imicola* (*Diptera: Ceratopogonidae*) in Europe. *Rev. Sci. Tech. Off. Int. Epiz.*, **20**, 731-740.

18. Zientara S., de La Rocque S., Gourreau J.M., Gregory M., Diallo A., Hendricks P., Libeau G., Sailleau C. & Delécolle J.-C. (2000). – La fièvre catarrhale ovine en Corse en 2000. *Epidémiol. Santé Anim.*, **38**, 133-144.

19. Zientara S., Grillet C., de La Rocque S., Gourreau J.M., Gregory M., Diallo A., Hendricks P., Libeau G., Sailleau C., Albina E., Bréard E. & Delécolle J.-C. (2001). – La fièvre catarrhale ovine en Corse en 2001. *Epidémiol. Santé Anim.*, **40**, 129-137.

20. Zientara S., Sailleau C., Dauphin G., Roquier C., Remond E.M., Lebreton F., Hammami S., Dubois E., Agier C., Merle G. & Bréard E. (2002). – Identification of bluetongue virus serotype 2 (Corsican strain) by reverse-transcriptase PCR reaction analysis of segment 2 of the genome. *Vet. Rec.*, **150**, 598-601.