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Culicoides biting midges in Spain: A brief overview

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ABSTRACT

The number of studies on insects of genus *Culicoides* Latreille, 1809 (Diptera, Ceratopogonidae) has increased considerably in Spain since 2000, mainly due to their role as vectors of arboviruses that cause disease in animals, especially ruminants. This paper aims to expose some general considerations about *Culicoides* biting midges in Spain.

Biting midges of the genus *Culicoides* Latreille, 1809 (Diptera, Ceratopogonidae) are minute haematophagous flies with veterinary relevance as vectors of internationally important arbovirus of livestock (Mellor et al., 2000). The greatest economic impact of *Culicoides* lies in their ability to transmit bluetongue virus (BTV), but also other arboviruses with interest in ruminant health as the recently emerged Schmallenberg virus (SBV) (Harrup et al., 2015). Regarding bluetongue, the infection ranges from asymptomatic, in the vast majority of infected animals, to fatal, in a proportion of infected sheep, goats, deer and some wild ruminants. Additional economic costs result from surveillance and control programs, reproductive losses, damaged wool and decreased milk production. The existence of multiple serotypes complicates control, as immunity to one serotype may not be cross-protective against others (CFSPH, 2015). In fact, twenty seven BTV serotypes have been recognized worldwide, including ten from Europe (Jenckel et al., 2015). Since 2000, four of these serotypes have been found in Spain (Rodríguez-Sánchez et al., 2010).

In the “Old World”, bluetongue had been linked traditionally with the presence of *Culicoides imicola*. However, in 2006 BTV-serotype 8 was reported from the countries in Northern and Western Europe (Thiry et al., 2006) where the species was not present, suggesting the possibility of other midge species could be involved in the transmission, especially in cooler regions. Nowadays, it is known that the European vectors for BTV are various species of *Culicoides* midges, most, but not all, from the subgenus *Avaritia* Fox, 1955: *Culicoides obsoletus* complex (*C. obsoletus* and *Culicoides scoticus*), *Culicoides chiopterus*, *Culicoides dewulfi*, *Culicoides pulicaris* complex (*C. pulicaris* and *Culicoides lupicaris*) and *C. imicola*. Other species such as *Culicoides montanus*, *Culicoides punctatus*, *Culicoides newsteadi* and *Culicoides nubeculosus* have been found positive to BTV genome, but their role in transmission is still unclear (Goffredo et al., 2015). The last update shows a total of 82 species of *Culicoides* in Spain (Sánchez Murillo et al., 2015), being all the above-mentioned reported in the country.

Taking into account the distribution range of the main vector species, *C. imicola* is well distributed across the dry Mediterranean area, while *C. obsoletus* complex is most abundant in the fully humid climates of Central and Northern Europe (Brugger and Rubel, 2013). In our country, *C. imicola* is mainly present in the drier Central and South-western part of continental Spain and mostly absent from the Northern more humid part. Occasionally, some specimens were also caught along the Ebro Valley and along the North-eastern Mediterranean coast, even sporadically in the Basque Country (Goldarazena et al., 2008). The population of this ceratopogonid peaks in the September–October period and it seems directly related to summer rainfall and soil texture (Alarcón-Elbal, 2015). The species has been reported entering into livestock premises (Calvete et al., 2009), although normally exhibits an exophagic behavior (Barnard, 1997). On the other hand, *C. obsoletus* complex is the most widespread group suggesting they may adapt to a wider range of eco-climatic circumstances than the other species, although the highest densities have been recorded in Northern Spain. The population of this species group peaks especially in

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May–June and then in mid-October, and it seems directly related with the presence of bovine hosts and substrates associated to livestock as breeding sites (Alarcón-Elbal, 2015). Adults show some degree of endophagy (Viennet et al., 2013).

In general, breeding sites of *Culicoides* species are poorly known. These Diptera can breed in a wide range of soils, if they provide enough moisture and organic matter to allow the development of the preimaginal stages, although each species has different preferences (Zimmer et al., 2013). *C. imicola* has been observed to prefer semi-moist breeding sites, and has been found in drainage canals and puddles created by leakage from water pipes, where soils are not subject to flooding (Mellor and Pitzolis, 1979; Foxi and Delrio, 2010). Meanwhile, *C. obsoletus* can develop in a wide range of habitats, including moist forest leaf litter, tree holes, standing water and marsh edges with vegetation, swamps, cattle manure and horse dung, among others (Ninio et al., 2011; González et al., 2013). The immature habitats of *C. scoticus* may coexist with *C. obsoletus* fairly regularly (Conte et al., 2007).

Carpenter et al. (2008) detail five main methods of controlling *Culicoides* midges: (a) application of insecticides and pathogens to larval habitats; (b) environmental interventions to remove larval habitats; (c) controlling adult midges by treating either resting sites, such as animal housing, or host animals with insecticides; (d) housing livestock in screened buildings, and; (e) using repellents or host kairomones to lure and kill adult midges.

Regarding the methods of larval control (a) and (b), a better knowledge of the microhabitats of *Culicoides* biting midges may allow the development of targeted species-specific vector control strategies (Zimmer et al., 2013). To date, no insecticidal products have been authorized specifically against *Culicoides* in the EU, although a wide range of products are available, licensed and in use against other arthropods of veterinary importance. Under restricted situations it may be feasible to reduce *Culicoides* populations by treatment of their breeding sites with the application of insecticides, but the high residual effect over other related species, animals and plants, resulted in a decline in the number of agents available for livestock pest management (EFSA, 2008). In order to minimize *Culicoides* breeding where possible, certain hygienic measures should be taken such as removal of animal litter, avoid drinking trough overflowing, take manure away from farm setting or dry or cover it with canvas, reduction of silage residues and treatment with methods such as composting and acidification (Zimmer et al., 2013; González, 2014).

In general, aerial and/or broad-scale ultra-low volume (ULV) spraying against adult *Culicoides* with insecticides (c) is unlikely to be environmentally acceptable. The direct application of insecticides to livestock present some drawbacks such as the need to calculate the optimal lethal doses, achieving optimal dispersal of the insecticide over the whole skin and taking into account the physiological characteristics of the animal (González, 2014). Nonetheless, vector control using residual spraying or application to livestock is recommended by many authorities to reduce BTV transmission (Venail et al., 2011). In this sense, some field trials that have assessed deltamethrin pour-on of livestock show a significant decrease in *Culicoides* feeding rates under field conditions for at least 35 day (Wehier et al., 2014), which is particularly relevant in situations when vaccination against BTV is not feasible such as with emergence of new serotypes of the virus. Additionally, deltamethrin, as well as many other synthetic pyrethroids has a significant repellent effect on certain ectoparasites.

Protective housing (d) has been investigated as a means of shielding animals from the majority of *Culicoides* attacks and hence arbovirus transmission, but the efficacy of this method can be difficult to estimate because the types and security of animal housing vary widely (Carpenter et al., 2008). Reducing biting risk through stabling appears to be a useful strategy for at least some livestock species, although it is almost impossible to cover all the entries in the livestock sheds. In addition, it is needed further research about the exophilic/endophilic behavior of the *Culicoides* present in each area (González, 2014).

Successful studies with repellents (e) (synthetic, natural repellents and non-host volatiles) have been performed in laboratory and field experimentation. However, absorption through the skin may reduce the effectiveness of these compounds and lead to potential problems of adverse reactions in the livestock and considerations of milk and meat withdrawal times (Carpenter et al., 2008). Otherwise, there has been an increasing interest in pull strategies with a proliferation of trap designs, but these are currently insufficiently developed for the reduction of the population of *Culicoides* over a large area (González, 2014).

In conclusion, for many *Culicoides* species, most aspects on their ecology and behavior remain undefined, and it hampers future control efforts. The consensus is that a holistic control strategy is needed. In particular, the combination of insecticides, attractants and repellents could provide an optimal control strategy, but further research is required on how this could be achieved for many different vector species (Logan et al., 2010).

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