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GUEST EDITORIAL

Honey bee colony losses

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Apiculture has been in decline in both Europe and the USA over recent decades, as is shown by the decreasing numbers of managed honey bee (*Apis mellifera* L.) colonies (Ellis *et al*., 2010; Potts *et al*., 2010). It therefore is crucial to make beekeeping a more attractive hobby and a less laborious profession, in order to encourage local apiculture and pollination. Apart from socio-economic factors, which can only be addressed by politicians, sudden losses of honey bee colonies have occurred, and have received considerable public attention. Indeed, in the last few years, the world's press has been full of eye catching but often uninformative headlines proclaiming the dramatic demise of the honey bee, a world pollinator crisis and the spectre of mass human starvation. "Colony Collapse Disorder" (CCD) in the USA has attracted great attention, and scientists there and in Europe are working hard to provide explanations for these extensive colony losses. Colony losses have also occurred elsewhere (Figs 1 and 2), but examination of the historical record shows that such extensive losses are not unusual (vanEngelsdorp and Meixner, 2009).

Almost exactly a century ago, in 1906, beekeepers on the Isle of Wight, a small island off the south coast of England, noticed that many of their honey bee colonies were dying, with numerous bees crawling from the hive, unable to fly. Despite some sceptical beekeepers suggesting that this was "paralysis", a condition which had long been known, the colony losses were widely reported in the media, and beekeepers became convinced that the cause was a novel

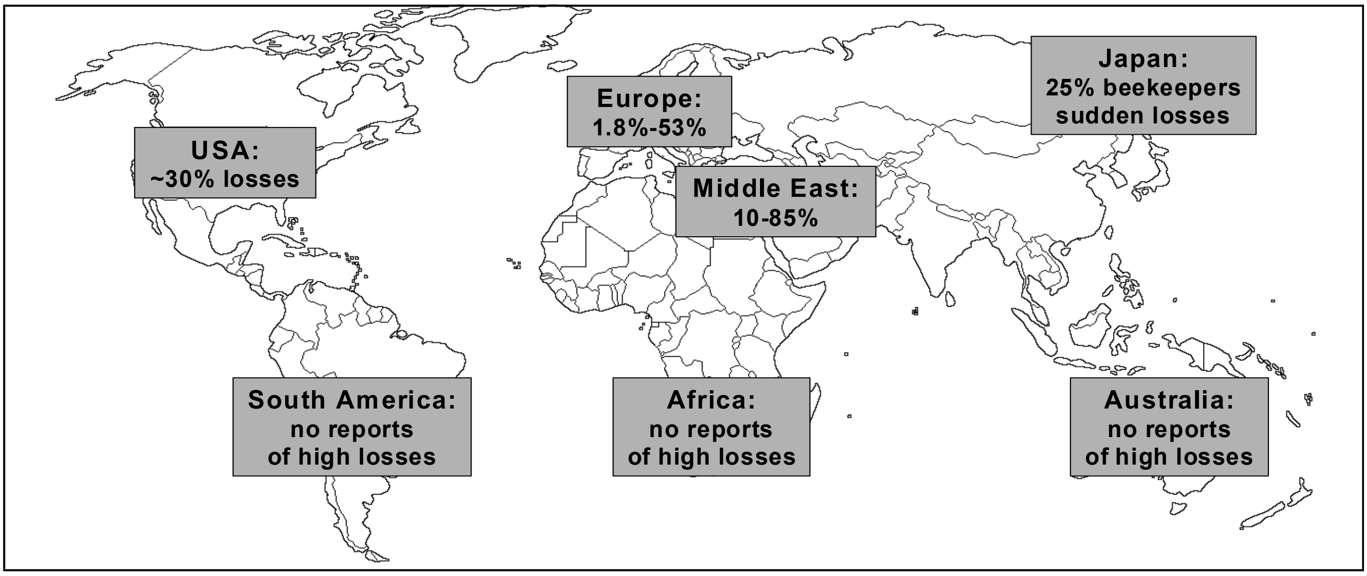

Fig. 1. The *Varroa destructor* equator of global colony losses. So far, elevated colony losses have recently been reported from Europe (Crailsheim *et al*., 2009), the USA (vanEngelsdorp *et al*., 2009; 2010), the Middle East (Haddad *et al*., 2009; Soroker *et al*., 2009), and Japan (Guttierrez, 2009), but not from South America, Africa and Australia. Colonies of African honey bees and Africanized honey bees in South America survive without *V. destructor* treatment, whilst the mite has not yet been introduced into Australia. This global picture indicates a central role of this particular ectoparasitic mite for colony losses.

and highly infectious disease, and the condition was soon reported from all parts of Britain. Within a few years, all losses of bees in Britain, from whatever cause, were ascribed to "Isle of Wight Disease" (Bailey and Ball, 1991; Bailey, 2002).

The response of the scientific community was instructive. Initially, the UK Government sent the eminent entomologist A D Imms to the Isle of Wight, but being unfamiliar with bees, he was unable to throw much light on the problem (Bailey and Ball, 1991). Other scientists soon made suggestions. By 1912, Fantham and Porter became convinced that the cause was the microsporidium *Nosema apis*, but this view was overshadowed by the discovery in 1919 of the tracheal mite *Acarapis woodi* (Rennie *et al.*, 1921). Conventional wisdom and beekeeping text books soon accepted that this impressive mite was the cause of the "Isle of Wight Disease", yet close examination of the original paper shows that this could not be so. Rennie *et al.*'s experimental results clearly demonstrated that some bees heavily infested with the mite were able to fly normally, yet other crawling bees, exhibiting the symptoms of the disease, contained no mites. One can only conclude that carried away by the excitement of their new discovery, they had failed to test Koch's Postulates, and had jumped to conclusions.

Sober reassessment of the "Isle of Wight Disease" many years later (Bailey and Ball, 1991; Bailey, 2002) led to the conclusion that the disease had been due to a combination of factors, in particular, infection by chronic bee paralysis virus (completely unknown at the time), together with poor weather which inhibited foraging, and an excess of bee colonies being kept for the amount of forage available.

The recent concern over CCD has much in common with the historical "Isle of Wight Disease" episode, and many lessons can be learned. Initial concern about colony losses in one particular area, the USA, has led to global media attention. Moreover, colony losses throughout the world are being ascribed to CCD, yet that term was

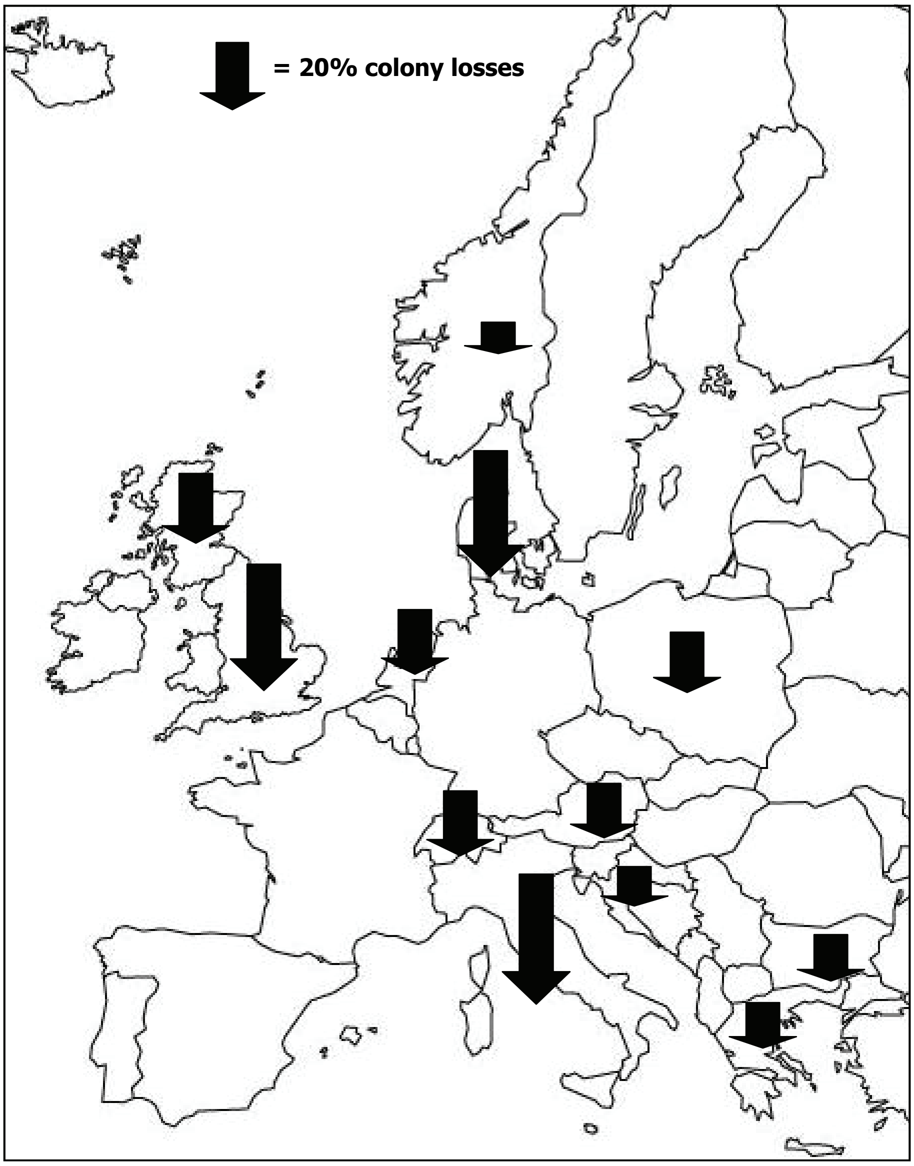

Fig. 2. Overview of recent colony losses in Europe. For details on individual countries please refer to papers in this Special Issue: Austria (Brodschneider *et al.*, 2010); Bulgaria (Ivanova and Petrov, 2010); Croatia (Gajger *et al.*, 2010); Denmark (Vejsnæs and Kryger, 2010); England (Aston, 2010); Greece (Hatjina *et al.*, 2010); Italy (Mutinelli *et al.*, 2010); Norway (Dahle, 2010); Scotland (Gray *et al.*, 2010); Switzerland (Charrière and Neumann, 2010).

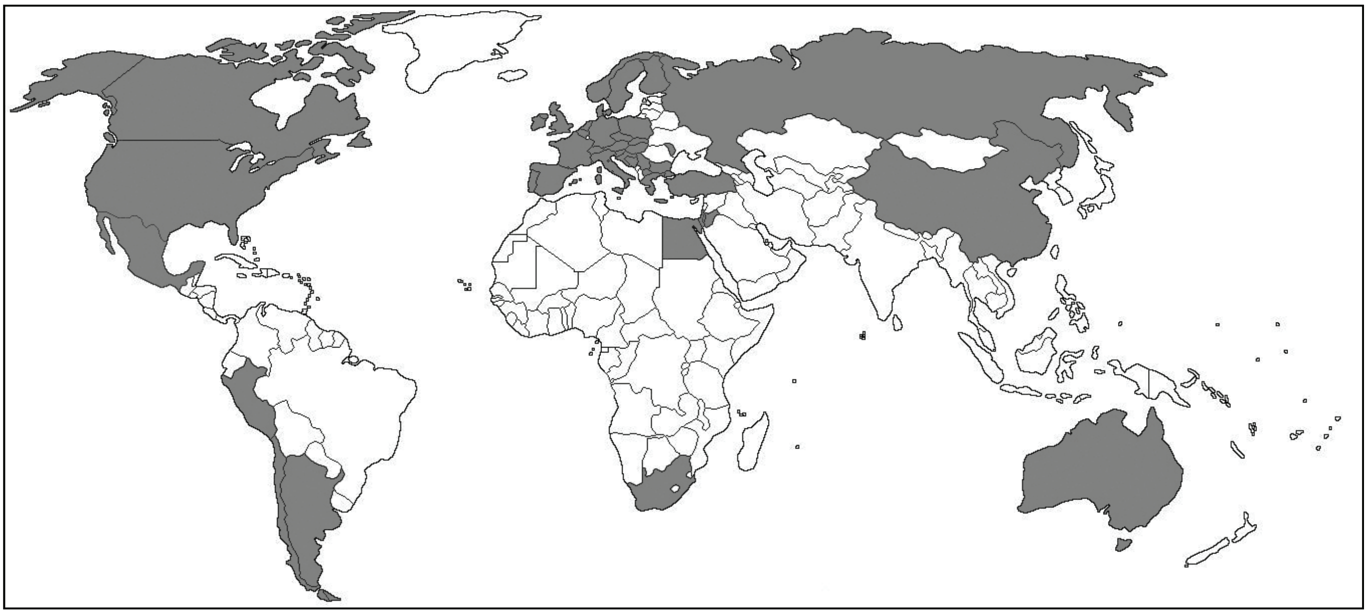

Fig. 3. The global COLOSS network ("Prevention of honey bee COLony LOSSes", consisting of 161 individual members from 40 countries (= grey areas).

specifically coined to describe a precisely defined set of symptoms (vanEngelsdorp *et al*., 2009) and not colony losses *per se*. Indeed, honey bee colonies can die in many ways, and CCD is just one of them (vanEngelsdorp *et al*., 2010). Finally, since both honey bee host and pathogens are genetically diverse, the symptoms and causes of colony losses may well be different in different regions.

Many well intentioned suggestions as to the possible causes of colony losses, including such improbable ideas as mobile telephones, genetically modified crops and nanotechnology, have perhaps overshadowed much more likely explanations such as pests and diseases, pesticides, loss of forage and beekeeping practices. For example, the long known major pest of *A. mellifera* apiculture, the ectoparasitic mite *Varroa destructor* has recently received comparatively little attention, but is certainly involved. Indeed, the broad patterns of CCD coincide with continents with different pressures from *V. destructor* (Fig. 1). Since African and Africanized honey bees survive without treatment for *V. destructor* (Martin and Medina, 2004), and the mite has not yet been discovered in Australia, this supports a central role of *V. destructor* for the current colony losses. In fact, data by Dahle (2010) strongly support this view, showing that regions with established mite populations had consistently higher losses than those without. After the development and dissemination of adequate mite control methods, however, losses due to *V. destructor* remained at tolerable limits until recently, suggesting that the mite alone cannot explain all of the recent losses.

Despite comprehensive recent research efforts on these colony losses, no single driver has yet emerged as the definitive cause of the phenomenon. Instead, interactions between multiple drivers are the most probable explanation for elevated over-wintering mortality, similar to the conclusions for the Isle of Wight disease (Bailey, 2002). At a global scale, most managed *A. mellifera* colonies are infested by *V. destructor*, facilitating the potential interaction between this factor and multiple other potential drivers almost anywhere in the world. Moreover, many other prominent honey bee pathogens are now also almost globally distributed, for example *Nosema* spp. and several viruses (Allen and Ball, 1996; Ellis and Munn, 2005; Maori *et al*., 2007; Fries, 2009). Multiple infections with pathogens and also interactions between pathogens and other suspected drivers of honey bee loss are therefore almost inevitable, at least in areas with established mite populations. Whilst the list of these other potential drivers is not novel, the evidence of such interactive effects, although limited, is important and growing. These interactions are particularly worrying, as sub-lethal effects of one driver could make another one more lethal; for example a combination of pesticides and pathogens.

Ascribing a definitive cause to losses has also been made much more difficult because of differing pathogen virulence and different host susceptibility in different regions, and different methods used by scientists in previous surveys and experiments. In order to eliminate this latter variability, an international standardisation of methods is urgently required (Nguyen *et al*., 2010). Moreover, the complex interactions between individual drivers of colony mortality and the high number of interacting factors easily exceed the research facilities of individual bee laboratories or even entire countries. Thus, efforts by individual countries to reveal the drivers of colony losses are probably doomed. The international COLOSS network (Prevention of honey bee COlony LOSSes) has therefore been created to coordinate efforts to explain and prevent large scale losses of honey bee colonies at a global scale (Figs 3 and 4). For that purpose, international standards will be developed for monitoring and research in the form of an online BEE BOOK, analogous to the RED BOOK of the *Drosophila* community (Lindsley and Zimm, 1992). Only this will enable collaborative large scale international research efforts to identify the

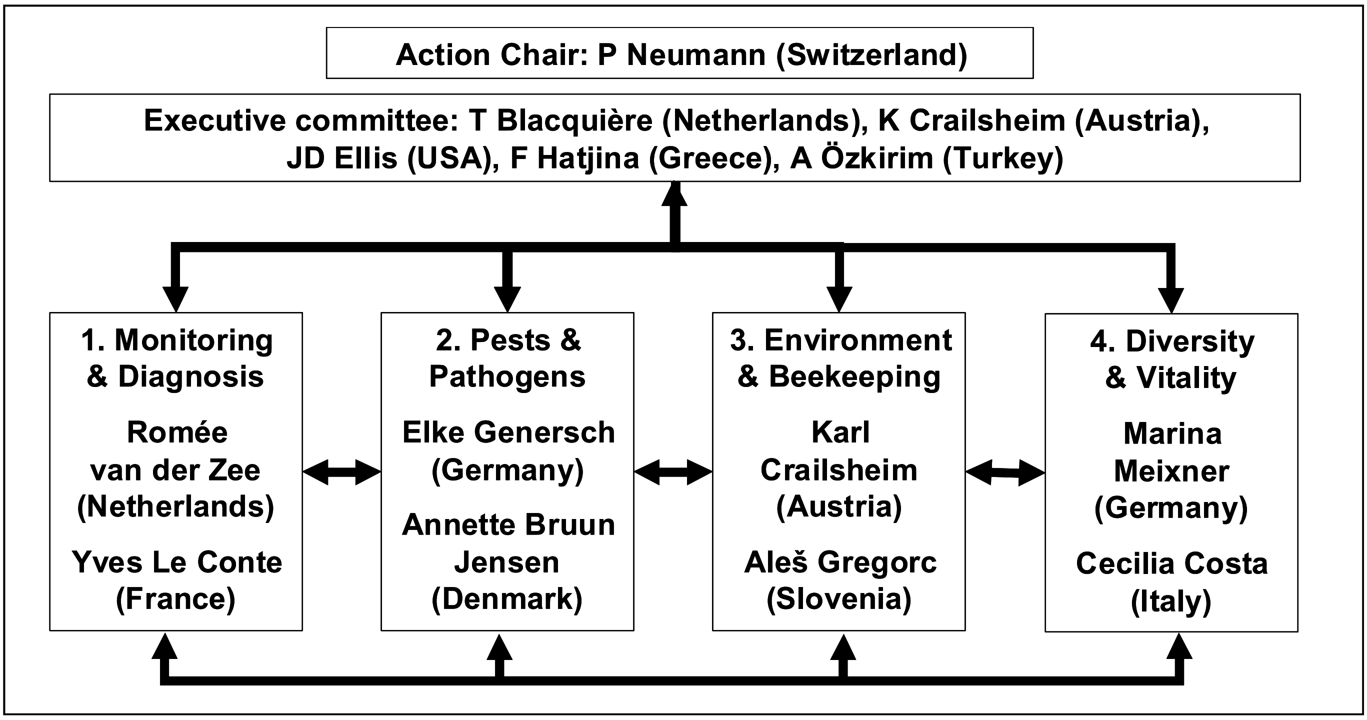

Fig. 4. Structure of the COLOSS network. Organizational matters are addressed by an executive core group. The four working groups (WG) concentrate on different aspects relevant for honey bee colony losses. WG 1 focuses on monitoring and diagnosis which are crucial to obtain reliable field data on losses, comparable between countries and years (Nguyen *et al.*, 2010). WGs 2-4 address in detail factors governing honey bee health at both individual and colony level (see Meixner *et al.*, 2010 for WG4). Co-operation across working groups is fundamental to address the interactions between factors driving mortality (e.g. between pathogens and pesticides for WGs 2 and 3).

underlying factors and mechanisms, such as global ring tests conducted to ensure common practices across diagnostic laboratories. These efforts appear critical for the development of adequate emergency measures and sustainable management strategies.

The COLOSS network does not directly fund research, but aims to coordinate national research activities across Europe and worldwide (Fig. 4). COLOSS comprises all three groups of stakeholders; scientists, beekeepers and industry with the aim of complementing rather than duplicating research approaches, and to create transnational synergies. Initiatives to obtain sustainable support for the network are in preparation. Networking is facilitated through conferences and scientific exchange programmes, but more importantly also through a large series of workshops for extension specialists and apiculturists. Only if we succeed in bridging the gap between bee science and apiculture will we achieve sustainable progress in the prevention of colony losses at a global scale.

For these reasons, this Special Issue of the *Journal of Apicultural Research* addresses the subject of colony losses. A mixture of Original Research Articles, Review Articles and Notes and Comments address the possible causes of honey bee colony losses: viruses (Berthoud *et al.*, 2010; Carreck *et al.*, 2010a,b; Martin *et al.*, 2010); *Nosema ceranae* (Paxton, 2010; Santrac *et al.*, 2010); *Varroa destructor* (Carreck *et al.*, 2010b; Dahle, 2010; Martin *et al.*, 2010); pesticides (Chauzat *et al.*, 2010b; Medrzycki *et al.*, 2010); the effects of acaricides (Harz *et al.*, 2010); the loss of genetic diversity (Meixner *et al.*, 2010; and loss of habitats (Potts *et al.*, 2010). In addition, gathered together for the first time in one place, a group of papers report on colony losses and possible causes in sixteen individual countries: Austria (Brodschneider and Crailsheim, 2010; Brodschneider *et al.*, 2010); Bosnia and Herzegovia (Santrac *et al.*, 2010); Bulgaria (Ivanova and Petrov, 2010); Canada (Currie *et al.*, 2010); Croatia (Gajger *et al.*, 2010); Denmark (Vejsnæs and Kryger, 2010); England (Aston, 2010); France (Chauzat *et al.*, 2010a,c); Greece (Hatjina *et al.*, 2010); Italy (Mutinelli *et al.*, 2010); the Netherlands (Van der Zee, 2010); Norway (Dahle, 2010); Poland (Topolska *et al.*, 2010); Scotland (Gray *et al.*, 2010); Switzerland (Charrière and Neumann, 2010); and the USA (Ellis *et al.*, 2010; vanEnglesdorp *et al.*, 2010). Finally, two further papers consider the general status of both managed honey bees (Potts *et al.*, 2010) and non-*Apis* bees (Roberts and Potts, 2010) in Europe.

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